# *Annual Receiving Waters Monitoring Report*

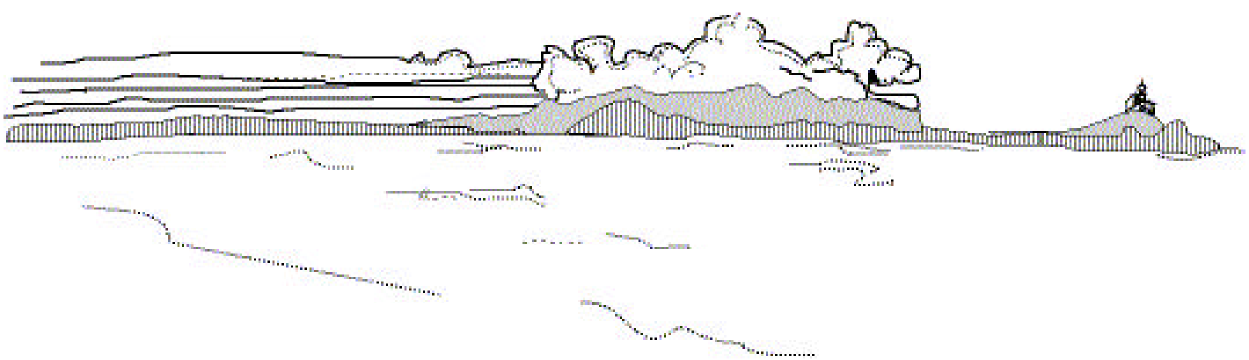
for the City of San Diego

**South Bay Water Reclamation Plant**

Discharge to the Pacific Ocean

through the South Bay Ocean Outfall

**2002**




City of San Diego

Metropolitan Wastewater Department

Environmental Monitoring and Technical Services Division
Ocean Monitoring Program



July 2003

THE CITY OF SAN DIEGO

July 1, 2003

Mr. John Robertus
Executive Officer
Regional Water Quality Control Board
San Diego Region
9174 Sky Park Court, Suite 100
San Diego, CA 92123

Attention: POTW Compliance Unit

Dear Sir:

Enclosed is the 2002 Annual Receiving Waters Monitoring Report for NPDES Permit No. CA0109045, Order No. 2000-129, for the City of San Diego South Bay Water Reclamation Plant (SBWRP) discharge to the Pacific Ocean through the South Bay Ocean Outfall. This report contains data summaries and statistical analyses for the various portions of the ocean monitoring program, including oceanographic conditions, microbiology, sediment characteristics, benthic infauna, demersal fishes and megabenthic invertebrates, and bioaccumulation of contaminants in fish tissues. These data are also presented in the International Boundary and Water Commission's annual report for discharge from the International Wastewater Treatment Plant (NPDES Permit No. CA0108928, Order No. 96-50).

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, I certify that the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Sincerely,

Alan C. Langworthy

ALAN C. LANGWORTHY
Deputy Metropolitan Wastewater Director

dp

Enclosure

cc: Department of Health Services, San Diego County
U.S. Environmental Protection Agency, Region 9
Metropolitan Wastewater Department Library, City of San Diego

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The City of San Diego

# *Annual Receiving Waters Monitoring Report*

for the

## South Bay Water Reclamation Plant

Discharge to the Pacific Ocean

through the South Bay Ocean Outfall

## 2002


Prepared by:

City of San Diego

Metropolitan Wastewater Department

Environmental Monitoring and Technical Services Division
Ocean Monitoring Program


July 2003

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**Chapter 6. Bioaccumulation of Contaminants in Fish Tissues**
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# Executive Summary

# Executive Summary

Receiving waters monitoring at fixed sites surrounding the South Bay Ocean Outfall (SBOO) is performed by the City of San Diego to fulfill requirements set forth in the NPDES permits for the South Bay Water Reclamation Plant and the International Wastewater Treatment Plant (see Chapter 1). The study area extends from the tip of Point Loma southward to Playa Blanca, Mexico, and from the shoreline seaward to depths up to about 61 m. Prior to the initiation of wastewater discharge on 13 January 1999, the City also conducted a 3½-year baseline monitoring program that was designed to characterize background environmental conditions surrounding the outfall and provide information against which post-discharge data may be compared. The City also conducts annual, region wide surveys of benthic conditions off the coast of San Diego as part of the NPDES permits for the SBOO. These regional surveys have been ongoing since 1994 and cover an area from about Del Mar southward to the U.S./Mexico international border. Such regional monitoring helps to evaluate patterns and trends over a larger geographic area, thus providing additional information that may help to distinguish reference areas from sites impacted by anthropogenic influences.

The present report focuses on the results of all SBOO monitoring conducted from January through December 2002. Fixed site sampling included monthly seawater measurements of physical and chemical parameters to document oceanographic conditions, as well as bacteriological samples to document water quality conditions in the region. Sediment samples were collected semiannually to monitor changes in sediment quality and benthic infaunal community structure. Trawl surveys were performed quarterly to characterize communities of bottom-dwelling fish and large invertebrates in the region (i.e., demersal fishes and megabenthic invertebrates). Chemical analyses of selected fish tissues were performed in order to quantify and document contaminant levels that may have ecological or human health implications. Finally, results of the July 2002 random sample survey of regional benthic sediment and infaunal conditions are included in Appendices D and E, respectively.

## OCEANOGRAPHIC CONDITIONS

Oceanographic conditions in the vicinity of the SBOO generally followed expected seasonal patterns in 2002. During winter, the water column was well-mixed with the physical parameters showing little depth-related variability. Surface waters began warming in mid-March with a strong thermocline becoming established by early summer. Although sea surface temperatures were generally lower than in previous years, mild weather conditions sustained a robust stratification and led to the development of an unusually shallow surface layer. These conditions persisted throughout the fall until increased mixing due to winter storms caused the thermocline to break down, resulting in a nearly homogeneous water column. Unlike previous years, there was little evidence of upwelling in 2002, although offshore conditions did lead to one mid-water plankton bloom in July. Despite lower than average rainfall during the year, transmissivity values reflected significant terrestrial input, with especially high turbidity occurring near the Tijuana River estuary. Overall, data for the region’s water column properties revealed little evidence of impact from anthropogenic sources.

## MICROBIOLOGY

Patterns of distribution of total coliform, fecal coliform and enterococcus bacteria for the SBOO region were generally similar in 2002 to that seen during previous years. These patterns appeared to be strongly influenced by seasonal oceanographic conditions, runoff from land and riverine sources, wastewater discharge, and other anthropogenic inputs. The lack of major storm activity and the presence of strong water column stratification were likely important factors in the apparent containment of the waste field throughout most of the year. For example, bacterial samples taken at discrete depths and fixed sites suggest that the wastewater plume typically remained offshore and at subsurface depths in the immediate vicinity of the outfall. Although the plume did reach the surface occasionally at sites located near the outfall terminus, this occurred only when the water column became thoroughly mixed. In addition, there were a few times during the Spring when elevated bacterial concentrations were detected in mid- and surface waters south of the outfall, which suggests that the waste field may have been transported south during these months. However, there was no evidence that the wastewater plume ever reached the shore. Instead, the distribution and frequency of high bacterial counts at shore stations near the mouth of the Tijuana River demonstrated the impact of the estuarine outflow, especially following rainfall events.

## SEDIMENT QUALITY

The composition and quality of ocean sediments near the SBOO were similar in 2002 to those observed during previous years. In general, sediment grain size increased with depth and the sediments at most sites consisted primarily of fine sands. Although there were differences in particle size composition between surveys and sites, these differences can be partly attributed to patches of sediments associated with multiple geologic origins (e.g., relict red sands, other detrital material). Sediments were coarsest at sites offshore and south of the SBOO**.** Finer materials, present at some shallow sites, are probably due to the deposition of sediments from the Tijuana River. In contrast, the presence of fine sediments at sites located north of the outfall may be related to the deposition of materials from San Diego Bay.

Anthropogenic influences on sediment quality were not evident from this monitoring. Concentrations of several organic indicators (i.e., total organic carbon, total nitrogen, sulfides) and various trace metals were generally low in SBOO sediments compared to other coastal areas off southern California, while other contaminants (e.g., pesticides) were detected infrequently. Similar to many other studies, the highest organic indicator and metal concentrations were associated with finer sediments. A derivative of the pesticide DDT was detected on only three occasions. Pesticides were already known to occur at these sites prior to construction of the outfall (see City of San Diego 1999). PCBs were also detected rarely in sediment samples, and all at levels well below the method detection limits. Although PAH compounds were also detected, they occurred only at sites located far north and south of the outfall and are unlikely to be related to wastewater discharge.

## BENTHIC COMMUNITIES

Benthic communities in the SBOO region consist of infaunal assemblages that vary along gradients of sediment structure (e.g., grain size) and depth (e.g., shallow vs. mid-depth waters). During 2002, shallow sites with sandy sediments were dominated by the spionid polychaete *Spiophanes bombyx*, a species characteristic of other shallow water assemblages in the Southern California Bight. Another type of assemblage occurred in slightly deeper waters north of the outfall, at sites where the sediments consisted of fine particles. This assemblage was dominated by the polychaetes *Lumbrineris latreilli, Euchone arenae* and *Lanassa venusta venusta*, and probably represents a transition between assemblages occurring in shallow sandy habitats and those occurring in finer mid-depth sediments off southern California. Finally, sites with sediments composed of relict red sands were also characterized by their own unique assemblages.

Patterns of species distribution and abundance also varied with depth and sediment type in the region, although there were no clear patterns with respect to the SBOO. The range of values for most community parameters in 2002 was similar to that seen in previous years. In addition, values of environmental disturbance indices such as the benthic response index (BRI) and infaunal trophic index (ITI) were characteristic of undisturbed sediments. Finally, changes in benthic community structure near the SBOO that occurred in 2002 were similar in magnitude to those that have occurred previously and elsewhere off southern California. Such changes often correspond to large-scale oceanographic processes or other natural events. Overall, benthic assemblages in the region remain similar to those observed prior to discharge and to natural indigenous communities characteristic of similar habitats on the southern California continental shelf. Consequently, there is no observed evidence from present monitoring efforts that wastewater discharge has resulted in any degradation of the benthos in the area.

## DEMERSAL FISH & MEGABENTHIC INVERTEBRATE COMMUNITIES

Speckled sanddabs dominated fish assemblages surrounding the SBOO in 2002. The overall dominance of speckled sanddabs was similar to that seen in previous years. These fish occurred at all stations and accounted for 76% of the total catch. Such results are expected because the shallow depths and coarse sediments in the area represent the typical habitat for this species. Other characteristic, but less abundant, species included the hornyhead turbot, spotted turbot, California halibut and California lizardfish. Most of these common fishes were relatively small, averaging less than 20 cm in length. Larger species included California halibut, Pacific angel shark, thornback and California skate. With the exception of California halibut, these fishes were collected less frequently.

As in previous years, the composition and structure of fish assemblages varied among stations. Differences in the total fish catch per haul were primarily due to variations in speckled sanddab populations. Although megabenthic community structure also varied between sites, these assemblages were generally characterized by low species richness, abundance, biomass and diversity.

Overall, no evidence has been observed that the discharge of waste water has affected either fish or megabenthic invertebrate communities in the region. Although highly variable, patterns in the abundance, biomass and number of species for these communities were similar at stations near the outfall and further away. In addition, no changes in these communities have been found to occur near the outfall that corresponds to the initiation of the discharge. Finally, the absence of any physical abnormalities on local fishes suggest that their populations continue to be healthy in the region.

## TISSUE CONTAMINANTS IN FISHES

There were no clear spatial patterns among the SBOO trawl or rig fishing stations in terms of fish tissue contaminants in 2002, and there was no evidence to suggest that fish contaminant loads were affected by the discharge of waste water from the SBOO. Although various contaminants were detected in both liver and muscle tissues, their concentrations were generally within ranges reported previously for fishes in the Southern California Bight. In addition, concentrations of most contaminants were not substantially different from those reported prior to discharge. Finally, samples of muscle tissues from sport fish collected in the area were found to be within FDA human consumption limits for both mercury and DDT.

The occurrence of both metals and chlorinated hydrocarbons in SBOO fish tissues may be due to many factors, including the ubiquitous distribution of many contaminants in coastal sediments off southern California. Other factors that affect the accumulation and distribution of contaminants include the physiology and life history of different fish species. Exposure to contaminants can vary greatly between species and even among individuals of the same species depending on migration habits. For example, fish may be exposed in a highly contaminated area and then move into one that is less contaminated. This is of particular concern for fishes collected in the vicinity of the SBOO, as there are many point and non-point sources that may contribute to contamination in the region.

# General Introduction

# Chapter 1

# General Introduction

The South Bay Ocean Outfall (SBOO) accepts treated effluent from two sources: the International Boundary and Water Commission's International Wastewater Treatment Plant (IWTP), and the City of San Diego's South Bay Water Reclamation Plant (SBWRP). Discharge from the IWTP began on January 13, 1999 and is performed under the terms and conditions set forth in Order No. 96-50, National Pollutant Discharge Elimination System (NPDES) Permit No. CA0108928. Discharge from the SBWRP began on May 6, 2002 and is performed under NPDES Permit No. CA0109045, Order No. 2000-129. These NPDES permits define the requirements for monitoring receiving waters around the SBOO, including the sampling plan, compliance criteria, laboratory analyses, statistical analyses and reporting guidelines.

Receiving waters monitoring for the South Bay region with respect to the above referenced permits is performed by the City of San Diego. The City also conducted a 3½-year baseline monitoring program prior to discharge in order to characterize background environmental conditions surrounding the SBOO (City of San Diego 2000a). The results of this baseline study provide background information against which the post-discharge data may be compared. In addition, the City has conducted annual region-wide surveys off the coast of San Diego since 1994 (e.g., see City of San Diego 1999, 2000b, 2001). Such regional surveys are useful in characterizing the ecological health of diverse coastal areas and may help to identify and distinguish reference sites from those impacted by wastewater discharge, stormwater input or other sources of contamination.

This report presents the results of monitoring that was conducted at fixed sites around the SBOO from January through December 2002, and meets requirements set forth in the SBWRP permit. Comparisons are also made to conditions during previous years in order to assess any outfall related changes that may have occurred (see City of San Diego 2000a, b, 2001, 2002). Each major component of the monitoring program is covered in a separate chapter: Ocecanographic Conditions, Microbiology, Sediment Characteristics, Benthic Infauna, Demersal Fishes and Megabenthic Invertebrates, and Bioaccumulation of Contaminants in Fish Tissues. In addition, the results of the July 2002 random sample survey of benthic sediments and organisms for the San Diego region are included in Appendices D and E, respectively. Appendix F describes the coastal remote sensing of the San Diego/Tijuana Region. Detailed information concerning station locations, sampling equipment, analytical techniques and quality assurance procedures are included in the Quality Assurance Manual for the City’s Ocean Monitoring Program (City of San Diego 2003). General and more specific details of these monitoring programs and sampling designs are given below and in subsequent chapters and appendices.

## SBOO MONITORING

The South Bay Ocean Outfall is located just north of the border between the United States and Mexico. It terminates approximately 5.6 km offshore at a depth of about 27 m. Unlike other southern California outfalls that are located on the surface of the seabed, the SBOO pipeline begins as a tunnel on land and then continues under the seabed to a distance of about 4.3 km offshore. From there it connects to a vertical riser assembly that conveys effluent to a pipeline buried just beneath the surface of the seabed. This pipeline then splits into a Y shaped multiport diffuser system, with the two diffuser legs extending an additional 0.6 km to the north and south. The outfall was designed to discharge and disperse effluent via a total of 165 diffuser risers. These include one riser located at the center of the outfall diffusers and 82 others spaced along each of the diffuser legs. However, low flow during the first several years of operation required closure of all ports along the northern outfall leg as well as many of those along the southern outfall leg. These closures are necessary to maintain sufficient back pressure within the drop shaft so that the outfall can operate in accordance with the theoretical model. Consequently, discharge during 2002 and previous years has been generally limited to the distal end of the south outfall leg, with the exception of a few intermediate points at or near the center of the outfall diffusers.

The regular SBOO sampling area extends from the tip of Point Loma southward to Playa Blanca, Mexico, and from the shoreline seaward to a depth of about 61 m, while the randomly selected benthic stations extend into deeper waters (see below). The offshore monitoring sites are arranged in a grid spanning the terminus of the outfall, and are monitored in accordance with NPDES permit requirements. Sampling at these fixed stations includes monthly seawater measurements of physical, chemical and bacteriological parameters in order to document water quality conditions in the area. Benthic sediment samples are collected semiannually to monitor infaunal communities and sediment conditions. Trawl surveys are performed quarterly to monitor communities of demersal fish and large, bottom-dwelling invertebrates in the region. Additionally, analyses of fish tissues are performed semiannually to document levels of chemical constituents that may have ecological or human health implications.

## RANDOM SAMPLE REGIONAL SURVEYS

The City of San Diego has conducted regional benthic monitoring surveys of randomly selected sites off the San Diego coast since 1994 in order to evaluate patterns and trends over a large geographic area. During the summers of 1994 and 1998, the City participated with other major municipal wastewater dischargers in large-scale surveys of the entire Southern California Bight, the 1994 Southern California Bight Pilot Project (SCBPP) and the 1998 Southern California Bight Monitoring Survey (Bight'98). An additional bightwide survey is scheduled to take place in the summer of 2003 (Bight'03). Results of the SCBPP and Bight'98 benthic surveys are available in Bergen et al. (1998, 2001), Noblet et al. (2002) and Ranasinghe et al. (2003). As part of monitoring efforts for the South Bay Ocean Outfall, the City of San Diego has used the same randomized sampling design in the surveys limited to the San Diego region (1995–1997 and 1999–2002).

The 2002 survey of randomly selected sites off San Diego covered an area from Del Mar south to the United States/Mexico border and extending offshore to depths up to about 202 m. All sampling was conducted during the month of July**.** This survey, along with previous regional surveys, used the USEPA probability-based EMAP sampling design in which a hexagonal grid was randomly placed over a map of the region. One sample site was then randomly selected from within each grid cell. This randomization helps to ensure an unbiased estimate of ecological condition (SCBPP 1994), and serves as an alternative to the fixed site design that is widely used in other compliance monitoring programs. Although 40 sites were initially selected for the 2002 survey, only 39 were successfully sampled for benthic infauna and sediments. Sampling at one site was unsuccessful due to the presence of a rocky reef, which made it impossible to collect samples.

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# Oceanographic Conditions

# Chapter 2

# Oceanographic Conditions

## INTRODUCTION

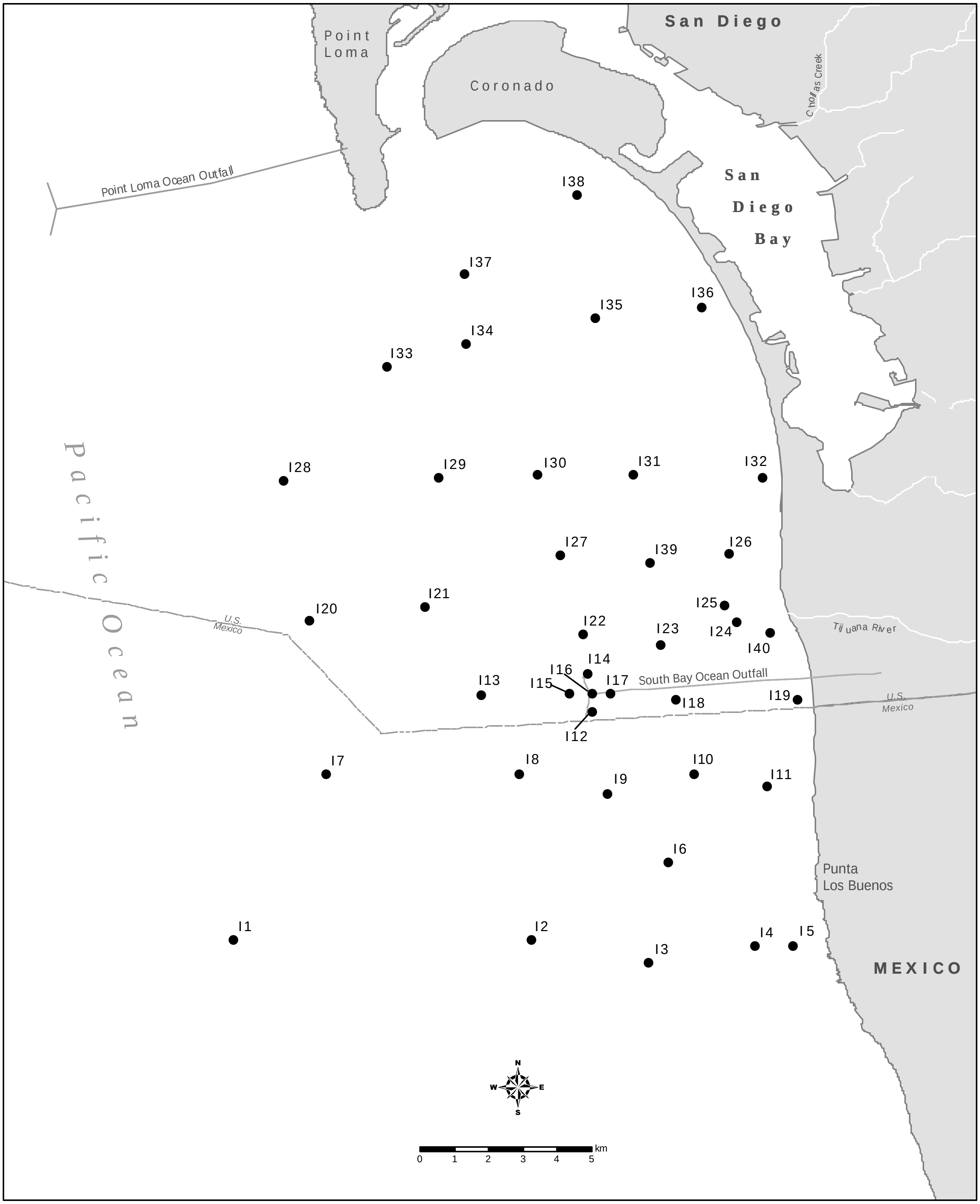
Measurements of physical and chemical parameters such as temperature, salinity, density, dissolve oxygen, etc. are important components of a discharge monitoring program because many of these properties determine water column mixing potential. Analysis of temporal and spatial variability of these parameters can also elucidate water mass movement. Moreover, these measurements help determine (1) deviations from expected patterns that may indicate influence of the wastewater plume from the outfall, and (2) the extent to which water mass movement or mixing reflects the dispersion/dilution potential for discharged material. With a deep offshore discharge, the fate of sewage-influenced waters is strongly determined by horizontal mixing through diffusion and currents as well as vertical mixing through diffusion, upwelling, or storm events. Oceanographic properties of the water column influence the degree of stratification and therefore measurements of physical parameters can characterize the vertical transport potential surrounding the South Bay Ocean Outfall (SBOO) throughout the year. On the other hand, in the absence of deepwater current information, bacterial concentrations may provide the best indication of horizontal transport of discharge waters (see Chapter 3).

Water quality in the South Bay marine environment is naturally variable but is also subject to various anthropogenic and natural sources of contamination such as discharge from the SBOO, San Diego Bay and the Tijuana River. To assess possible impacts from the outfall discharge, the City of San Diego regularly monitors oceanographic conditions of the water column. This chapter contributes to the investigation of SBOO impacts on the marine environment by analyzing the oceanographic conditions that occurred during 2002. Interpretation of water column conditions can then be referenced to help explain patterns of bacteriological occurrence (see Chapter 3).

## MATERIALS & METHODS

### Field Sampling

Oceanographic measurements were collected by lowering a SeaBird conductivity, temperature and depth (CTD) instrument through the water column at each of 40 fixed stations (see Figure 2.1). The stations form a grid encompassing an area of approximately 450 km$^2$ and were generally situated along 9, 18, 27, and 55-m depth contours. Thirty-seven stations are located in open-water from 3.4 km to14.6 km offshore. The remaining three stations (I-25, I-26 and I-39) are considered kelp bed stations and range between 1.3 and 3.1 km offshore.




# Figure 2.1

Locations of water quality monitoring stations surrounding the South Bay Ocean Outfall where CTD casts are taken .

Although these stations do not currently bear large kelp populations, they are situated in an area that once supported a significant Imperial Beach kelp bed and has the potential to do so again.

All 40 stations were sampled at least once each month by CTD over a 3-5 day period. Profiles of temperature, salinity, density, pH, transmissivity (water clarity), chlorophyll *a*, and dissolved oxygen values were constructed for each station by averaging the values recorded over 1-m depth intervals during processing. Further details regarding the CTD data processing are provided in the City's Quality Assurance Manual (City of San Diego, 2003). To meet the California Ocean Plan sampling frequency requirements for kelp bed areas, CTD casts for temperature and transmissivity only were conducted at the kelp stations an additional four times each month. Visual observations of weather and water conditions were recorded prior to each CTD sampling event.

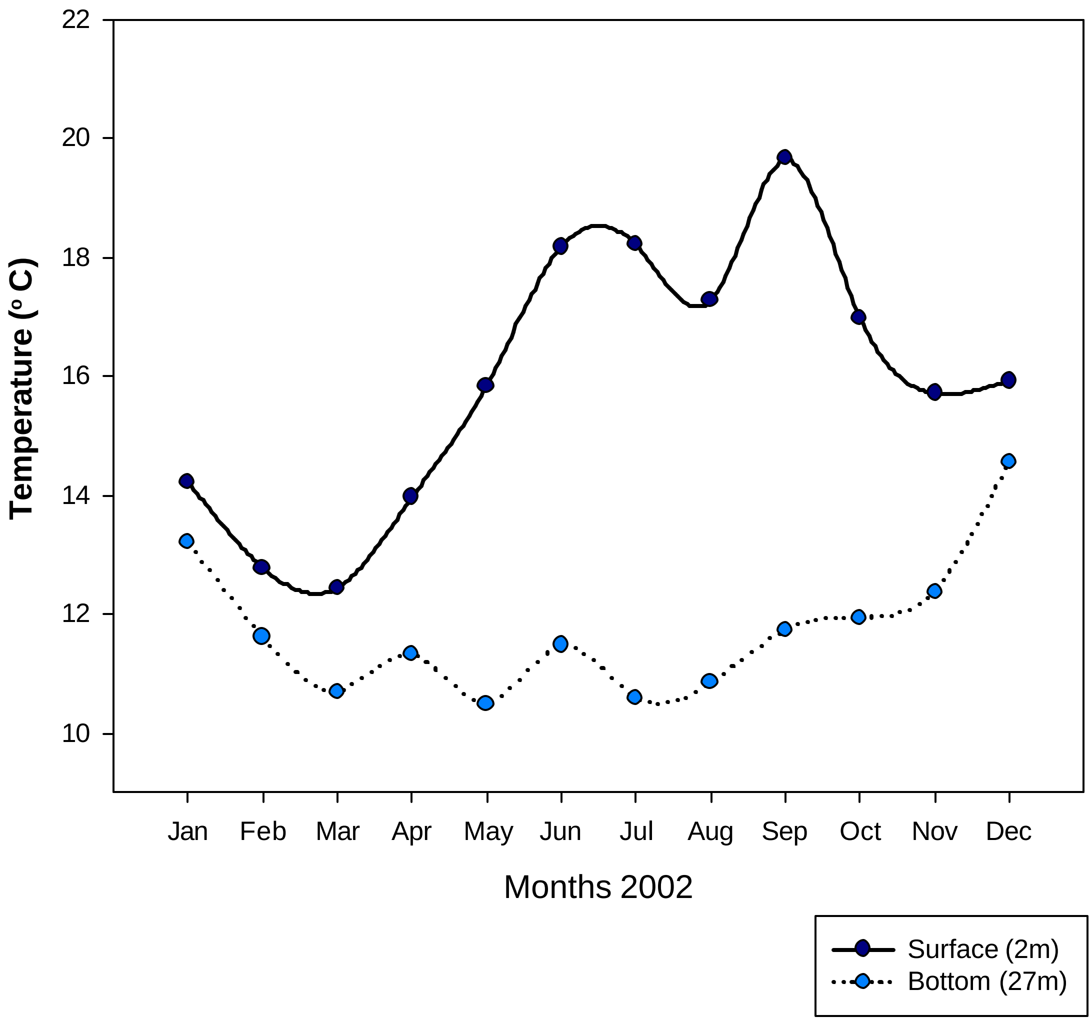



**Figure 2.2**

Monthly average temperatures for surface (≤ 2m) and bottom (≥27m) waters during 2002.

# RESULTS & DISCUSSION

## Expected Seasonal Patterns of Physical and Chemical Parameters

Southern California weather can be classified into two basic “seasons”, wet (Winter) and dry (Spring through Fall), and certain patterns in oceanographic conditions track these “seasons.” In the wet winters, water temperatures are cold and the water column is well-mixed resulting in similar properties in surface and deeper waters. In contrast, dry summer weather warms the surface waters and introduces thermally-sustained stratification. Despite a sampling schedule that limits oceanographers to snapshots in time spread out over several days during each month, analyses of oceanographic data collected from the South Bay region over the past eight years support this pattern.

Each year, typical winter conditions are present in January and February. A high degree of homogeneity within the water column is the normal winter signature for all physical parameters, although stormwater runoff may intermittently influence the density profile by causing a freshwater lens within nearshore surface waters. With little, if any, stratification of the water column, the chance that the wastewater plume may surface is highest during these winter months. Winter conditions can extend into March, when a decrease in the frequency of winter storms brings about the transition of seasons. The increasing elevation of the sun and lengthening southern California days begin to warm the surface waters and cause the return of a seasonal thermocline and pycnocline to coastal and offshore waters. Once stratification is established by late spring, minimal mixing conditions tend to remain throughout the summer and fall until cooler weather, reduced solar input, and increased stormy weather returns around September or October.

## Observed Seasonal Patterns of Physical and Chemical Parameters

Temperature is the main contributor to stratification in southern California waters (Dailey et. al., 1993) and provides the best indication of discharge plume surfacing potential. During 2002, thermal stratification of the water column followed the expected seasonal pattern (Figure 2.2). Stratification was minimal or absent from January through March with differences between average surface and bottom temperatures consistently less than 2$^{O}$C. Accordingly, temperature values varied little during these winter months: surface waters (above 2m) ranged between 11.4 and 15.1$^{O}$C, while bottom waters (below 27 m) closely tracked these changes and ranged between 10.2 and 14.0$^{O}$C. Beginning in April, however, the temperatures between surface and bottom waters began to diverge as the surface waters began to warm.

From May through October, there was a difference of at least 3$^{O}$C between surface and bottom temperatures and sometimes as great as 10$^{O}$C. Individual surface water measurements ranged from 13.4 to 20.8$^{O}$C, while bottom waters ranged from 9.8 to 12.8$^{O}$C during these months. Almost all stations recorded a change greater than 1$^{O}$C from one CTD measurement to the next (i.e., within 1 m of water depth) suggesting there was strong thermal stratification throughout the summer and fall. Interestingly, Figure 2.2 shows a temporary cooling of the

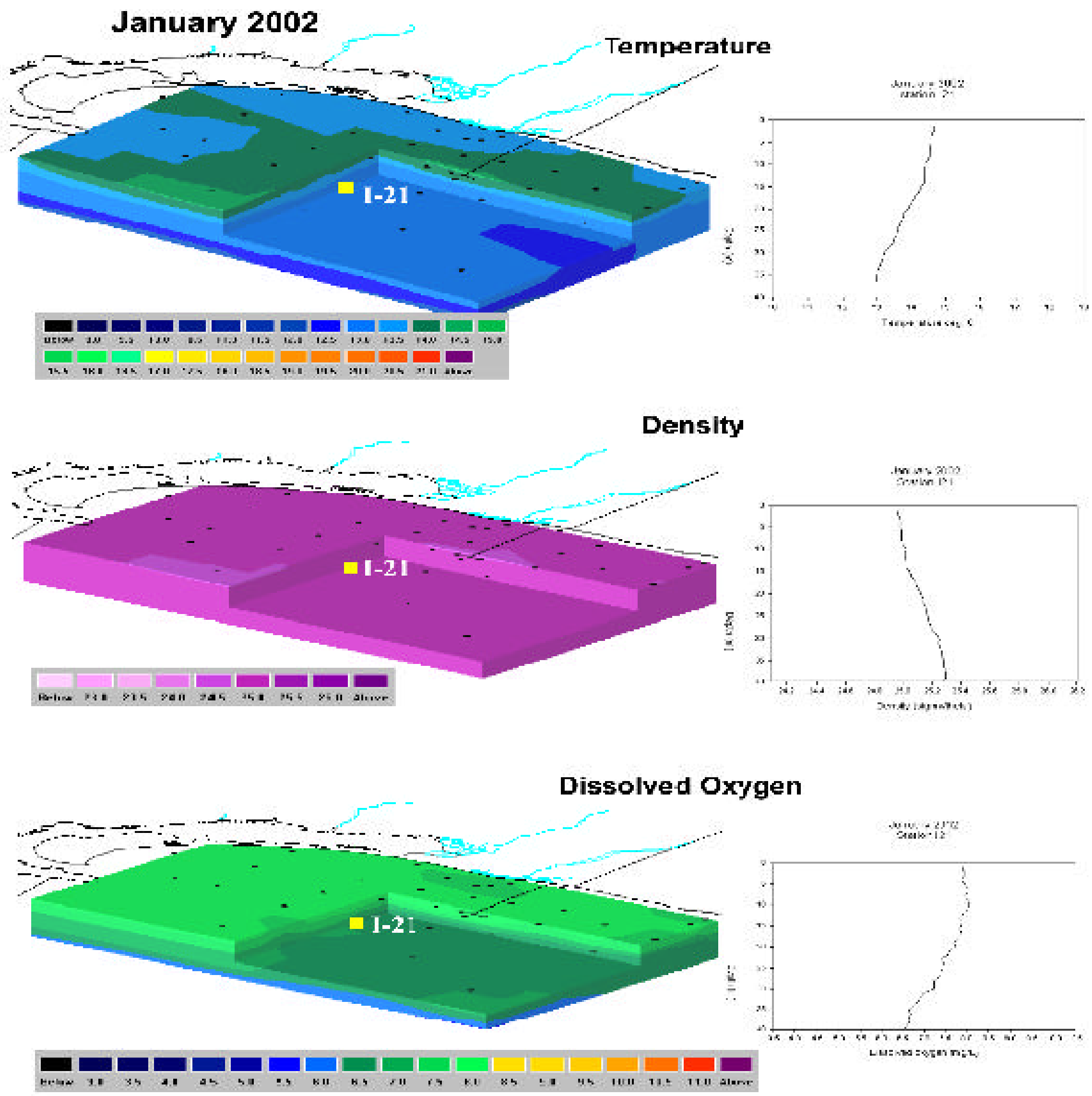
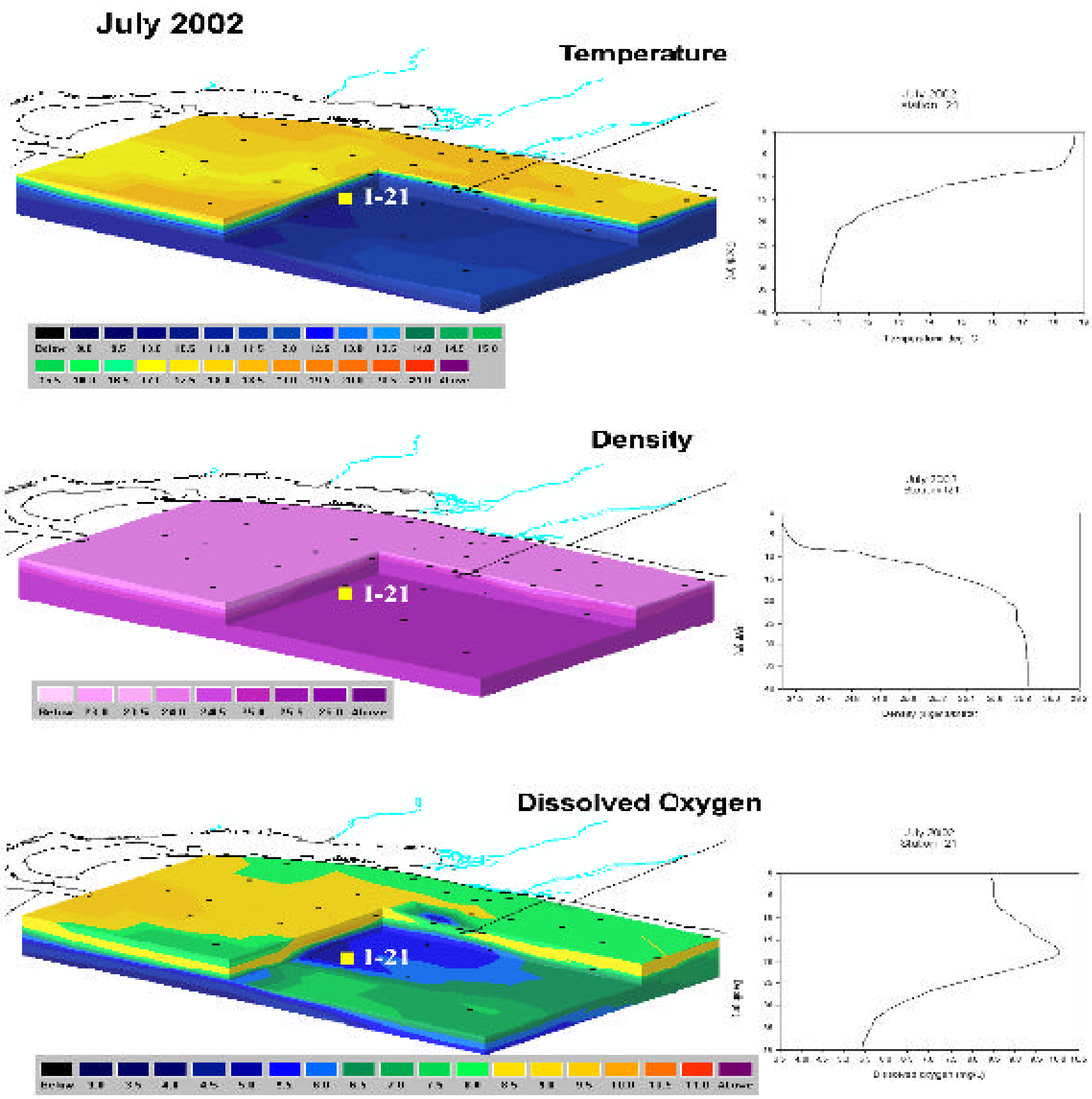



**Figure 2.3**

Interpolated volumetric (3D) plots of temperature, density (*/2), and dissolved oxygen at stations surrounding the SBOO on January 7th, 9th and 10th, 2002. Accompanying profiles illustrate these same parameters for a specific offshore station, I21, on January 9th, 2002.




## Figure 2.4

Interpolated volumetric (3D) plots of temperature, density (*/2), and dissolved oxygen at stations surrounding the SBOO on July 1 - 3, 2002. Accompanying profiles illustrate these same parameters for a specific offshore station, I21, on July 2nd, 2002.

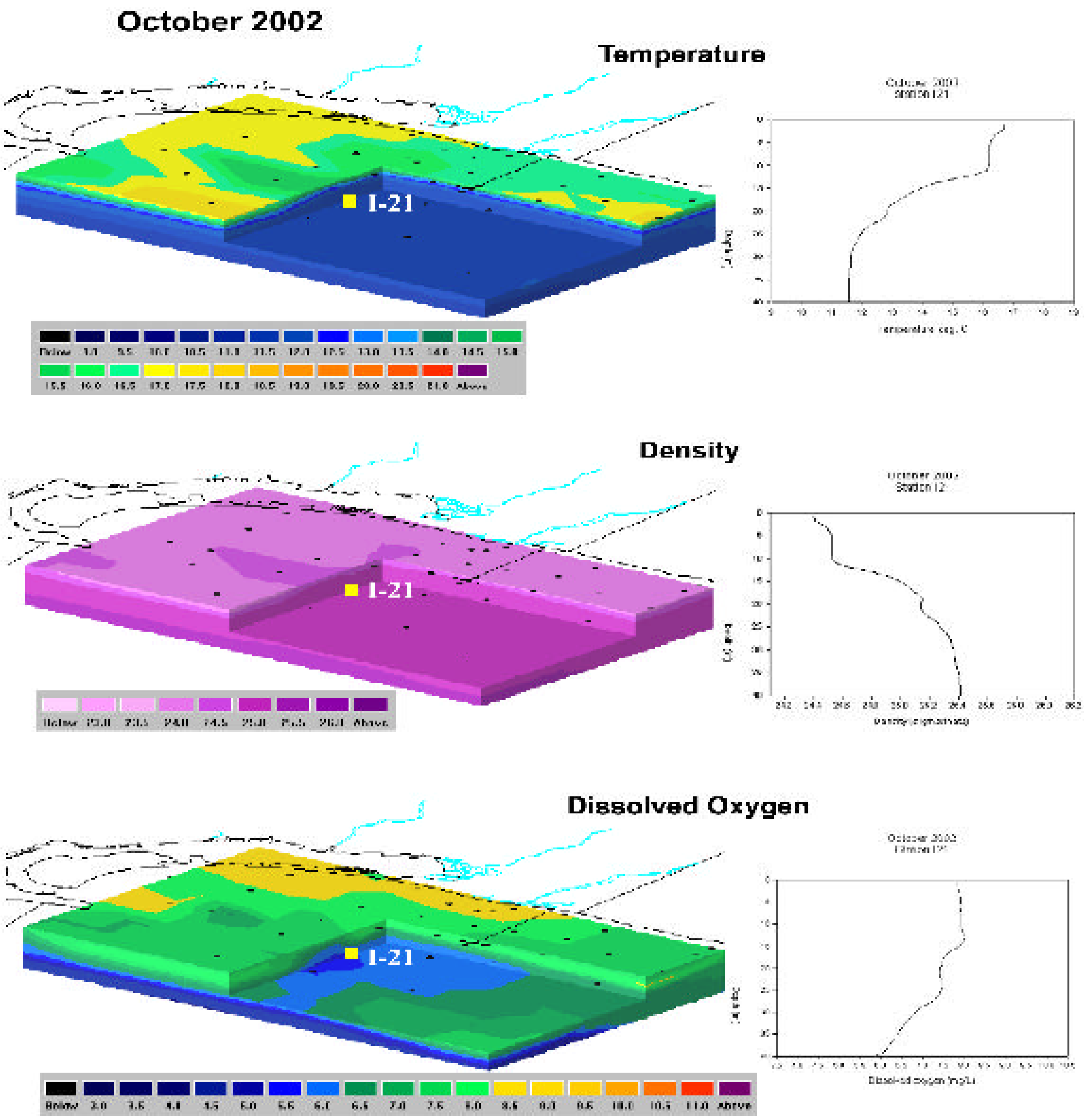



**Figure 2.5**
Interpolated volumetric (3D) plots of temperature, density (*/2), and dissolved oxygen at stations surrounding the SBOO on October 1 - 3, 2002. Accompanying profiles illustrate these same parameters for a specific offshore station, I21, on October 3rd, 2002.

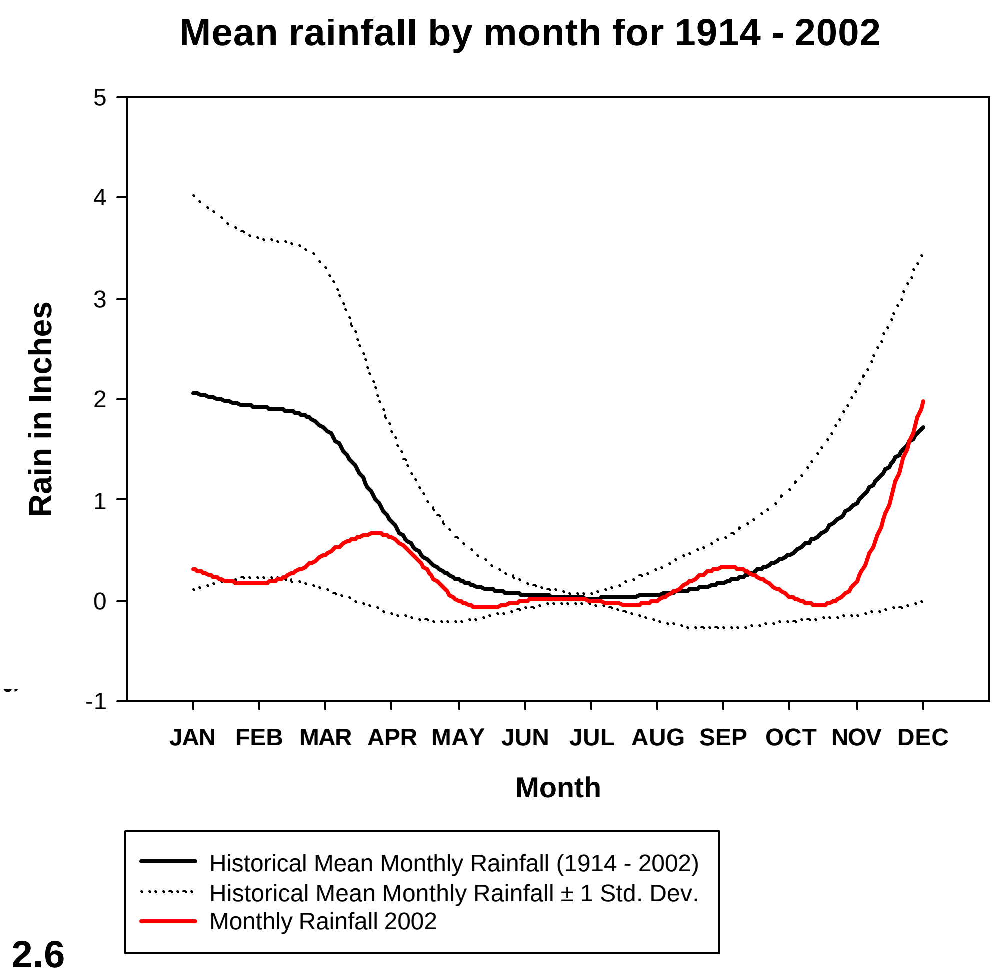



**Figure 2.6**

Monthly average rainfall at Lindberg Field (San Diego, CA) for 2002 compared to normal monthly average rainfall for the historical period 1914 through 2002.

surface waters that occurred during the month of August when the average temperature fell nearly a full degree from that seen in July. In September, average surface temperatures reached 19.7$^{O}$C, the year's highest level. Bottom water temperatures remained fairly constant (between 10 and 12$^{O}$C) throughout the spring, summer and fall months. As mixing increased in the fall, the bottom waters warmed noticeably. Deep water intrusion from southern equatorial waters may also have contributed to the warming. By December, bottom temperatures reached an average of 14$^{O}$C and had returned to within 2$^{O}$C of the surface water temperatures.

These temperature conditions are apparent in single-station profiles and all-station volumetric interpolations of data collected during January, July and October (Figures 2.3 – 2.5). The density and dissolved oxygen plots corroborate the seasonal patterns of water column stratification and mixing that were apparent from temperature data. The thoroughly mixed and homogeneous water column present January through March is represented by the January plots (Figure 2.3). The transition to stratified conditions began in March, continued throughout April and strengthened in May. Stratification was very strong and consistent throughout summer and fall (Figures 2.4 and 2.5). In November increased mixing induced greater water column homogeneity. Finally, in December, despite significant freshwater input from rains (see Figure 2.6), stratification disappeared and the water column returned to a thoroughly mixed state similar to that found the previous January (see Figure 2.3).

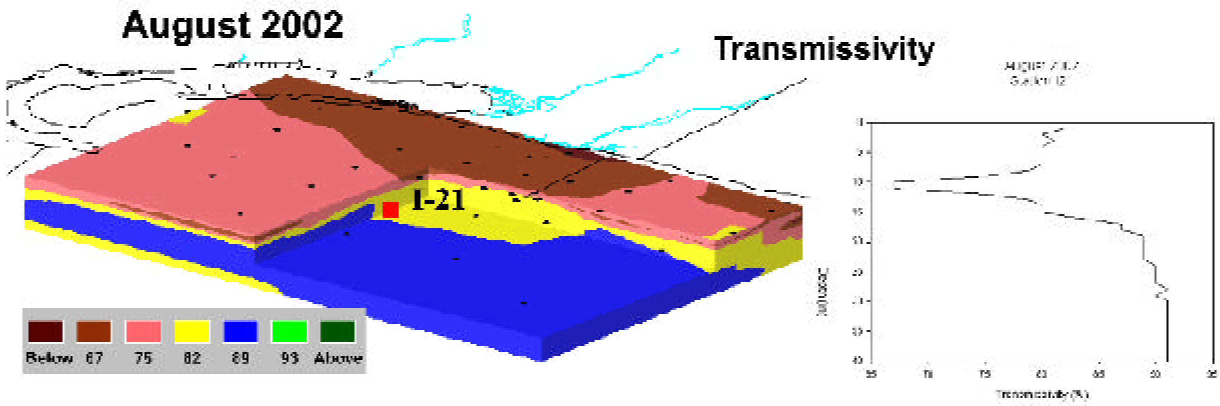



**Figure 2.7**

Interpolated volumetric (3D) plot of transmissivity at stations surrounding the SBOO on August 5 - 7, 2002. Accompanying profile illustrates transmissivity for station I21, on August 7, 2002

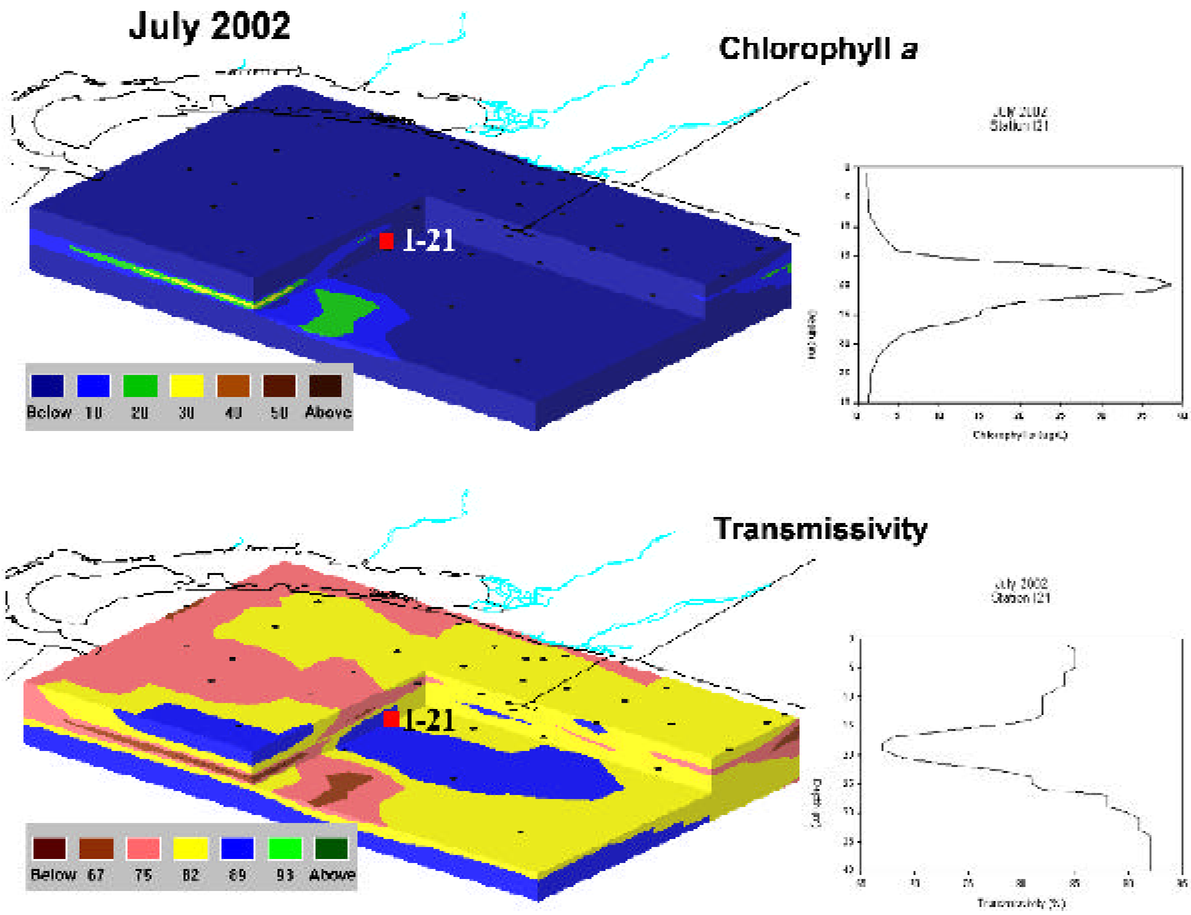
Although most physical parameters tracked very well with expected seasonal changes in 2002, overall calm conditions, low rainfall and a lack of storm activity led to an unusually shallow thermocline during the spring, summer and fall months. The average offshore thermocline depth in April was 26 m; however, it was at 6 – 10 m deep by July and remained above 12 m for most of the summer. The shallow surface layer likely caused stronger than normal stratification and shoreward trapping of terrestrial contributions.

Despite almost no rainfall to cause runoff (see Figure 2.6), nearshore transmissivity values were low throughout the summer (see August transmissivity plot in Figure 2.7). Water clarity was consistently an issue directly south of the mouth of San Diego Bay as well as offshore of the Tijuana River. As an indicator of terrestrial contributions, riverine and Bay water influence on nearshore waters also explains the nearshore bacterial results further discussed in Chapter 3. While transmissivity values in surface waters were rarely below 70% near the outfall terminus, almost every station exhibited significantly lower transmissivity values within 3 m of the bottom. Resuspension of bottom sediments was the likely cause of these low values near the bottom, and this effect complicated efforts to determine any deep horizontal movement of plume waters from transmissivity data.

In general, the density of phytoplankton (i.e., chlorophyll *a* concentrations) did not have a significant impact on water clarity. The only confirmed plankton bloom occurred in July (see Figure 2.8). In September, elevated chlorophyll concentrations just offshore of the Tijuana River also correlated with low transmissivity values (Figure 2.9), but the source of the chlorophyll was unknown. Outside of these two events, chlorophyll values were consistently low throughout the water column for most sampling events.

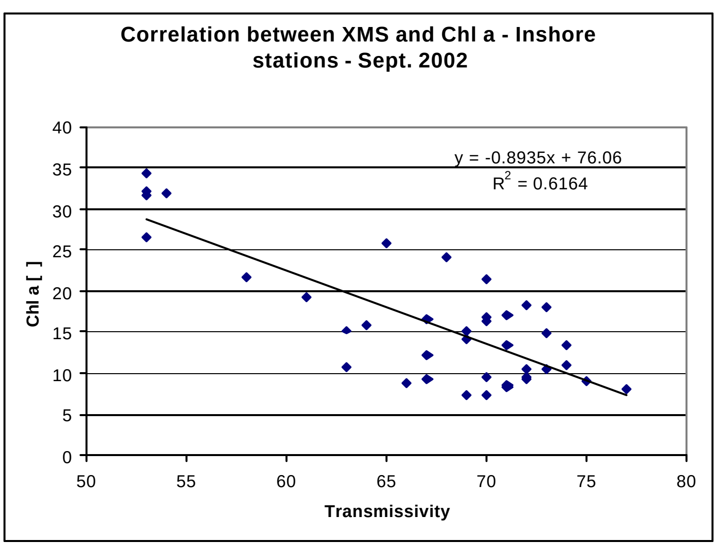
## SUMMARY & CONCLUSIONS

Oceanographic conditions during 2002 were within expected annual variability and followed normal seasonal patterns. Rainfall was lower than average, sea state was generally calm, and there were few major storm events




## Figure 2.8

Interpolated volumetric (3D) plots of chlorophyll and transmissivity at stations surrounding the SBOO during July 1 - 3, 2002. Accompanying profiles illustrate these same parameters for station I21, on July 3, 2002.




## Figure 2.9

Correlation between transmissivity and chlorophyll *a* concentrations at stations I-19, I-24, I-25, I-26 and I-40 during September 2002.

prior to mid-December. There was no evidence of upwelling, and only one large summer plankton bloom was observed.

Other than this plankton bloom and the nearshore turbidity present in September, reduced water clarity was rarely associated with high chlorophyll concentrations. Flow from San Diego Bay and the Tijuana River appeared to heavily influence transmissivity values in those localized areas. Low transmissivity in bottom waters occurred at every station and was likely due to resuspended sediments, while surface waters surrounding the outfall terminus had high transmissivity levels similar to distant open water stations.

Although sea surface temperatures infrequently reached the high temperatures typical of summer, the overall mild weather conditions allowed a strong, shallow thermocline to persist from April through October. The robust stratification throughout most of the year ensured that plume surfacing was only possible during a few winter months. These oceanographic conditions contribute to the observed spatial patterns of bacterial concentrations discussed in the following chapter.

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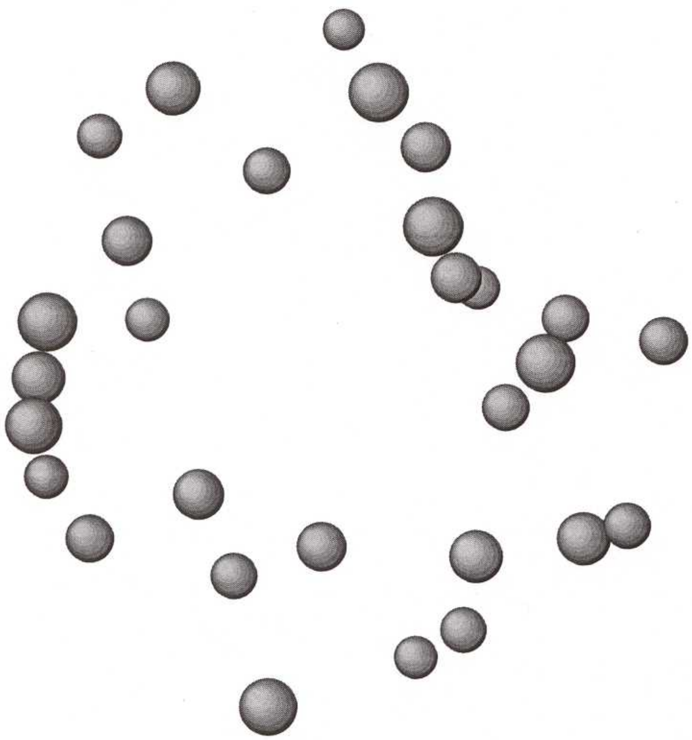
# Microbiology



# Chapter 3

# Microbiology

## INTRODUCTION

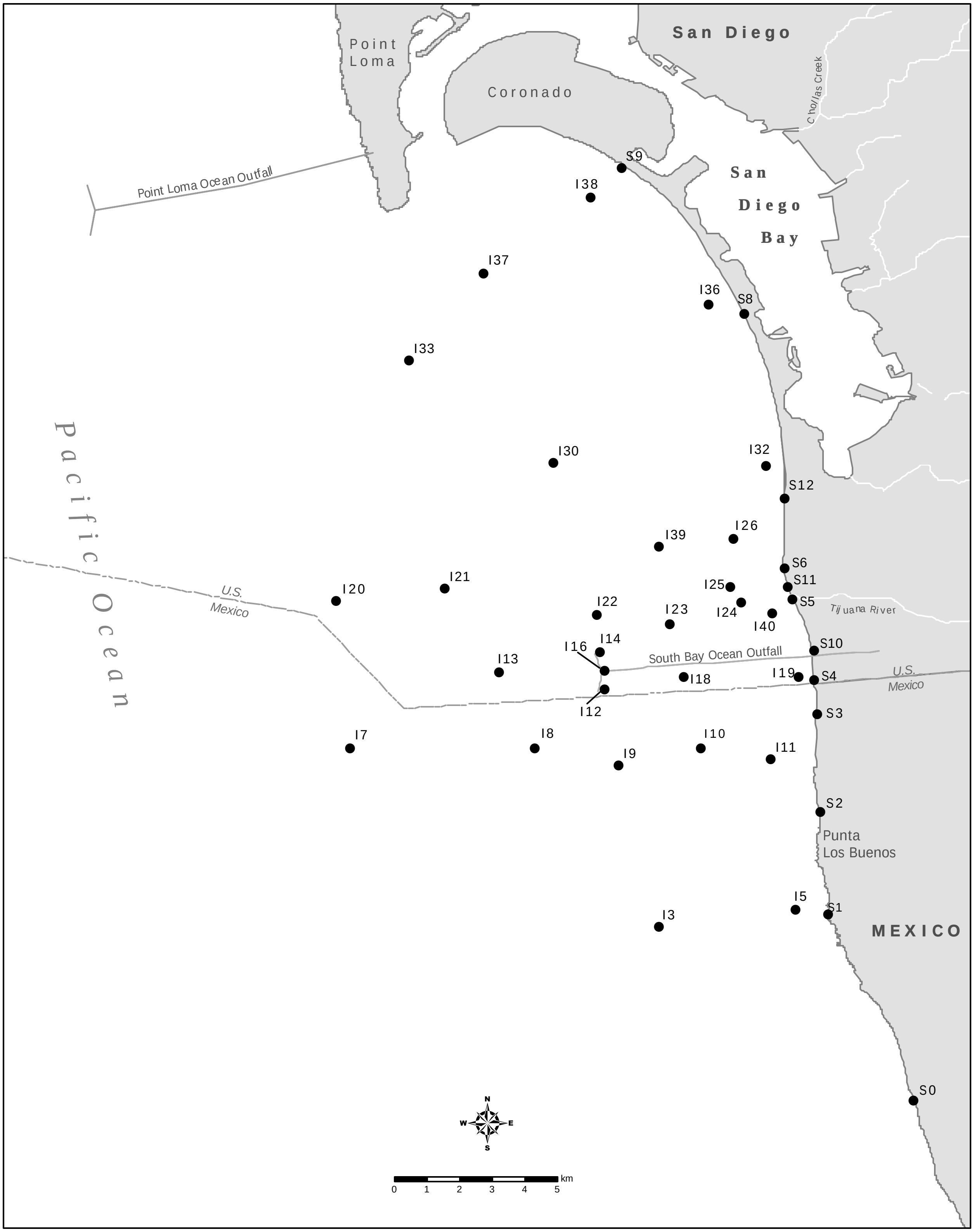
The City of San Diego performs shoreline and water column bacterial monitoring in the region surrounding the South Bay Ocean Outfall (SBOO). The presence, absence and abundance of bacteria, together with physical parameter data (see Chapter 2), can provide information about the movement and dispersion of wastewater discharged through the outfall. Analyses of these data may also implicate point or non-point sources other than the outfall as contributing to bacterial contamination events in the region. The SBOO monitoring program is designed to assess general water quality and demonstrate level of compliance with the California Ocean Plan (COP) as required by the NPDES discharge permit. This chapter summarizes and interprets bacterial concentration data collected during 2002.

## MATERIALS & METHODS

### Field Sampling

Water samples for bacterial analysis were collected at fixed shore and offshore sampling sites throughout the year (Figure 3.1). Weekly sampling was performed at eleven shore stations to monitor bacteria levels along public beaches. Four stations (stations S-0, S-1, S-2, and S-3) were located south of the international border along the coast from Playa Blanca, Mexico to the US/Mexico border, and are not subject to COP water contact standards. Only three of these sites were sampled at any one time. Sampling at station S-1 was abandoned in July 2002 as a result of restricted access that prevented sample collection on several successive occasions. Sampling at the substitute station (S-0) began on August 13, 2002. Eight other sites (stations S-4 through S-6, S-8 through S-12) were located within the United States and extend from the border northward to Coronado. These shoreline stations are subject to water contact standards. Twenty-eight offshore stations were sampled monthly at three discrete depths, usually over a 3-day period. These offshore sites were located in a grid pattern surrounding the outfall, along the 9, 18, 27, 37, and 55-m depth contours. Three stations (I-25, I-26 and I-39) are considered kelp bed stations subject to the COP water contact standards. These stations were sampled for bacterial analysis an additional four times each month in accordance with NPDES permit requirements. Although no cohesive bed exists at this time, the area has supported kelp beds in the past.

Seawater samples from the shore stations were collected from the surf zone in sterile 250-mL bottles, and visual observations of water color and clarity, surf height, human or animal activity, and weather conditions were recorded at the time of collection. The seawater samples were then transported on ice to the City's Marine




# Figure 3.1

Locations of water quality monitoring stations where bacterial samples are taken surrounding the South Bay Ocean Outfall.

Microbiology Laboratory and analyzed to determine concentrations of total coliforms, fecal coliforms and enterococcus bacteria.

Offshore samples were analyzed for the same three bacterial parameters, as well as total suspended solids, and oil and grease. The water samples were collected using either a series of Van Dorn bottles or a rosette sampler fitted with Niskin bottles. Aliquots for each analysis were drawn into appropriate sample containers. The samples were refrigerated on board ship and then transported to either the City’s Marine Microbiology Laboratory for bacterial analysis or to the City’s Wastewater Chemistry Laboratory for analysis of oil and grease, and suspended solids. Visual observations of weather and water conditions were also recorded at the time of sampling.

### Laboratory Analyses

All bacterial analyses were performed within six hours of sample collection and conformed to the membrane filtration techniques outlined in the City’s Quality Assurance Manual (City of San Diego, 2003). The Marine Microbiology Laboratory follows guidelines issued by the EPA Water Quality Office, Water Hygiene Division and the California State Department of Health Services, Water Laboratory Approval Group with respect to sampling and analytical procedures (Bordner, et al., 1978; Greenberg, et al., 1992).

Colony counting, calculation of results, data verification and reporting all follow guidelines established by the EPA (see Bordner, et al. 1978). According to these guidelines, plates with bacterial counts above or below permissible counting limits were given “>”, “<“, or “e” (estimated) qualifiers. These qualifiers were ignored and the counts were treated as discrete values during the calculation of compliance with COP standards and various statistical analyses.

Quality assurance tests were performed routinely on water samples to insure that sampling variability did not exceed acceptable limits. Duplicate and split field samples were generally collected each month and processed by laboratory personnel to measure intra-sample and inter-analyst variability, respectively. Results of these procedures were reported in the Quality Assurance Manual (City of San Diego, 2003).

## RESULTS & DISCUSSION

### Compliance with California Ocean Plan Standards – Shore and Kelp Bed Stations

California Ocean Plan (COP) bacterial standards for U.S. shore and kelp stations are displayed in Box 3.1. Water samples collected from the four northernmost shore stations and in the nearshore coastal waters were generally compliant with COP standards (Table 3.1). In contrast, water quality at shore stations and nearshore stations within the zone of influence of the Tijuana River were frequently compromised. The 2002 findings follow the same spatial pattern observed in previous years (City of San Diego, 2002).

**Box 3.1**

Bacteriological compliance standards for water contact areas, 2001 California Ocean Plan. CFU = colony forming units.

(1) *30 day total coliform* — no more than 20% of the samples at a given station in any 30-day period may exceed a concentration of 1000 CFU per 100 mL.

(2) *10,000 total coliform standard* — no single sample, when verified by a repeat sample collected within 48 hrs, may exceed a concentration of 10,000 CFU per 100 mL.

(3) *60 day fecal coliform* — no more than 10% of the samples at a given station in any 60-day period may exceed a concentration of 400 CFU per 100 mL.

(4) *geometric mean* — the geometric mean of the fecal coliform concentration at any given station in any 30-day period may not exceed 200 CFU per 100 mL, based on no fewer than 5 samples.

The four northernmost shore stations (S-6, S-8, S-9 and S-12) were compliant with the 30-day total coliform and 60-day fecal coliform standards over 88% of the time (Table 3.1). Station S-8 was in full compliance with both standards for the entire year. In contrast, stations S-4, S-5, S-10 and S-11 located within the Tijuana River zone of influence, often did not comply with these standards. The Tijuana River is a known source of bacteriological contamination and the proximity of these four stations to the river mouth may explain the frequency with which they were out of compliance. Station S-5, located closest to the river mouth, appears to have been the site most influenced by river discharge. It had the lowest compliance record for both the 30-day total and 60-day fecal coliform standards: 58 and 61%, respectively.

Bacterial concentrations at all three kelp stations were 100% compliant with the 60-day fecal coliform standards. These stations also had compliance levels for the 30-day total coliform standard of 93% or greater. The occasional high bacterial concentrations that caused these exceptions to the 30-day standard occurred in the winter months of January, February and December. Exceedence of the standard at all three stations in December was due to very high total coliform values measured on December 22 and 24. However, the January and February exceedences suggest that the calculation method for the 30-day standard frequently underestimates compliance. Because there are a limited number of sampling days each month, even moderately high values on one day can cause a station to be subsequently considered out of compliance for up to two weeks of non-sampled days. For example, stations I-25 and I-26 exceeded the 30-day compliance threshold in January as a result of moderately high values recorded on January 6 (between 1,000 and 4,000 CFU/100 mL) and very high values reported from the previous December. Similarly, the exceedence at I-26 in February was due to the moderately high total coliform values from January 6. Finally, the February exceedence at station I-39 was due to moderate total coliform levels recorded on February 8 (1,200 and 3,600 CFU/100 mL). The fact that fecal coliform levels were consistently

## Table 3.1

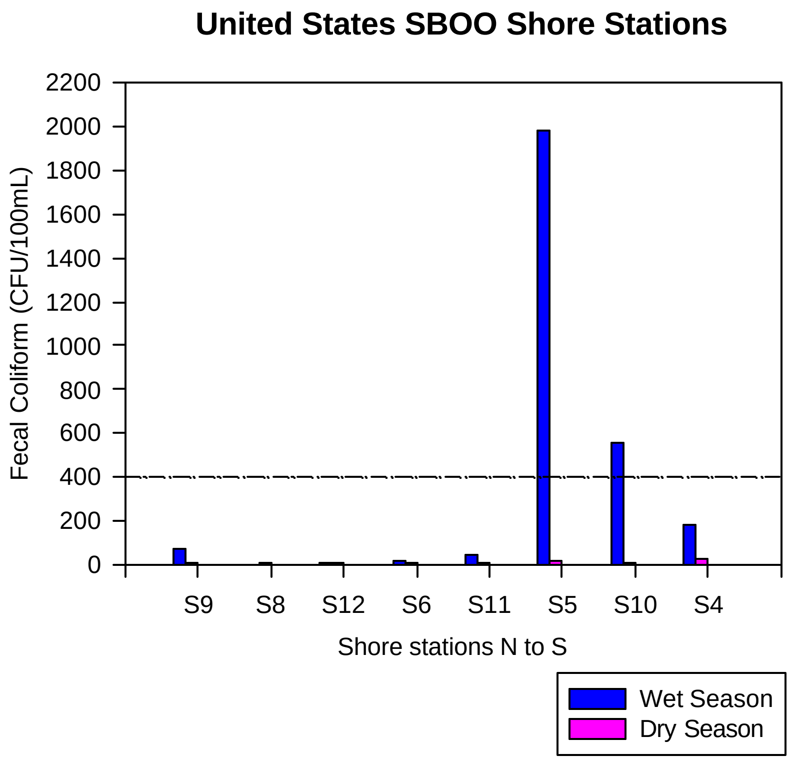
Summary of compliance with California Ocean Plan water contact standards for SBOO shore and kelp stations during 2002. The values reflect the number of days that each station exceeded the 30-day total and 60-day fecal coliform standards. Shore stations are listed left to right from north to south.

**30-Day Total Coliform Standard**

| | | Shore Stations | | | | | | | | Kelp Stations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Month** | **# of possible sampling days** | **S9** | **S8** | **S12** | **S6** | **S11** | **S5** | **S10** | **S4** | **I-25** | **I-26** | **I-39** |
| January | 31 | 0 | 0 | 1 | 0 | 0 | 2 | 2 | 1 | 13 | 13 | 0 |
| February | 28 | 0 | 0 | 0 | 0 | 0 | 28 | 27 | 24 | 0 | 1 | 15 |
| March | 31 | 0 | 0 | 0 | 0 | 0 | 27 | 12 | 26 | 0 | 0 | 0 |
| April | 30 | 0 | 0 | 0 | 10 | 11 | 17 | 27 | 27 | 0 | 0 | 0 |
| May | 31 | 0 | 0 | 0 | 10 | 15 | 29 | 10 | 10 | 0 | 0 | 0 |
| June | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| July | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| August | 31 | 0 | 0 | 0 | 7 | 7 | 7 | 0 | 12 | 0 | 0 | 0 |
| September | 30 | 0 | 0 | 0 | 12 | 12 | 12 | 0 | 7 | 0 | 0 | 0 |
| October | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 |
| November | 30 | 0 | 0 | 0 | 0 | 8 | 13 | 0 | 4 | 0 | 0 | 0 |
| December | 31 | 0 | 0 | 0 | 5 | 12 | 20 | 14 | 14 | 10 | 10 | 4 |
| **Percent non-compliance** | | **0%** | **0%** | **0%** | **12%** | **18%** | **42%** | **25%** | **38%** | **6%** | **7%** | **5%** |
| **Percent compliance 2002** | | **100%** | **100%** | **100%** | **88%** | **82%** | **58%** | **75%** | **62%** | **94%** | **93%** | **95%** |

**60-Day Fecal Coliform Standard**

| | | Shore Stations | | | | | | | | Kelp Stations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Month** | **# of possible sampling days** | **S9** | **S8** | **S12** | **S6** | **S11** | **S5** | **S10** | **S4** | **I-25** | **I-26** | **I-39** |
| January | 31 | 0 | 0 | 30 | 0 | 0 | 12 | 4 | 0 | 0 | 0 | 0 |
| February | 28 | 3 | 0 | 1 | 0 | 0 | 28 | 28 | 0 | 0 | 0 | 0 |
| March | 31 | 13 | 0 | 0 | 0 | 0 | 31 | 31 | 13 | 0 | 0 | 0 |
| April | 30 | 6 | 0 | 0 | 0 | 1 | 30 | 12 | 30 | 0 | 0 | 0 |
| May | 31 | 0 | 0 | 0 | 0 | 12 | 23 | 6 | 18 | 0 | 0 | 0 |
| June | 30 | 0 | 0 | 0 | 0 | 12 | 12 | 0 | 0 | 0 | 0 | 0 |
| July | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| August | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| September | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| October | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| November | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| December | 31 | 0 | 0 | 0 | 0 | 0 | 8 | 14 | 15 | 0 | 0 | 0 |
| **Percent non-compliance** | | **6%** | **0%** | **8%** | **0%** | **7%** | **39%** | **26%** | **21%** | **0%** | **0%** | **0%** |
| **Percent compliance 2002** | | **94%** | **100%** | **92%** | **100%** | **93%** | **61%** | **74%** | **79%** | **100%** | **100%** | **100%** |




## Figure 3.2

Average fecal coliform concentrations for SBOO shore stations during wet months (January –April) versus dry months (May – October) for 2002.

low at all three kelp stations suggests that the associated elevated total coliform values were probably not related to wastewater discharge.

### Temporal Variabilty – Shore Stations

The annual average fecal concentrations were very low in 2002, especially when compared to the very wet El Niño year of 1998 (Figure 3.2). However, high bacterial monthly means for the shore stations nearest the Tijuana River (S-4, S-5, S-10 and S-11) during fall, winter and spring suggests that river discharge influences bacterial concentrations along the shore (Table 3.2). Comparison of fecal coliform concentrations during wet versus dry months and during El Niño versus normal years provided further evidence of the river's influence. For 2002, the wet season fecal concentrations are dramatically higher than dry season concentrations at S-4, S-5 and S-10 (Figure 3.3), but were still quite low in comparison to historical values (see Figure 3.2).

To further explore the association between rainfall and bacterial concentrations, a linear regression was performed to determine if a correlation existed between the two parameters. The results indicated that there was no correlation ($r^2 = 0.03$) between the two. However, a qualitative comparison using only the bacterial values that exceeded specific benchmark thresholds did provide evidence of a relationship (Table 3.3). Bacterial samples with total coliform concentrations greater than 1,000 CFU/100 mL and a fecal to total coliform ratio of 0.1 or

## Table 3.2

Shore station bacterial densities and rainfall data for the SBOO region during 2002. Mean total coliform, fecal coliform and enterococcus bacterial densities are expressed as CFU/100 mL. Mean rainfall is expressed in inches as measured at Lindberg Field, San Diego, CA.

| **Month (Rain)** | Stations (n) | S9 (54) | S8 (53) | S12 (53) | S6 (53) | S11 (55) | S5 (58) | S10 (58) | S4 (57) | S3 (51) | S2 (51) | S1 (25) | S0 (19) | **All station** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Jan** | Total | 8 | 17 | 18 | 45 | 14 | 5,481 | 5,378 | 637 | 878 | 621 | 3,448 | | **1,504** |
| **(0.3)** | Fecal | 2 | 4 | 11 | 26 | 8 | 326 | 820 | 8 | 19 | 327 | 226 | | **162** |
| | Entero | 6 | 13 | 67 | 16 | 10 | 271 | 65 | 18 | 28 | 266 | 35 | | **72** |
| **Feb** | Total | 3,212 | 9 | 6 | 7 | 5 | 3,494 | 16 | 486 | 306 | 1,679 | 763 | | **907** |
| **(0.2)** | Fecal | 271 | 4 | 5 | 2 | 3 | 2,428 | 5 | 20 | 32 | 111 | 54 | | **267** |
| | Entero | 30 | 31 | 6 | 5 | 5 | 2,412 | 9 | 7 | 25 | 41 | 51 | | **238** |
| **Mar** | Total | 6 | 18 | 18 | 10 | 32 | 6,715 | 6,413 | 5,452 | 4,147 | 384 | 807 | | **2,182** |
| **(0.5)** | Fecal | 6 | 3 | 7 | 5 | 5 | 4,804 | 1,230 | 642 | 467 | 8 | 29 | | **655** |
| | Entero | 4 | 2 | 8 | 20 | 7 | 2,590 | 26 | 28 | 223 | 13 | 29 | | **268** |
| **Apr** | Total | 2 | 2 | 60 | 615 | 3,987 | 3,512 | 1,156 | 900 | 1,018 | 3,221 | 3,218 | | **1,608** |
| **(0.6)** | Fecal | 2 | 2 | 19 | 42 | 162 | 712 | 26 | 16 | 26 | 132 | 603 | | **158** |
| | Entero | 2 | 2 | 13 | 4 | 16 | 65 | 3 | 26 | 32 | 54 | 74 | | **26** |
| **May** | Total | 26 | 15 | 162 | 31 | 39 | 1,818 | 127 | 85 | 123 | 12 | 4,030 | | **588** |
| **(Trace)** | Fecal | 27 | 3 | 25 | 2 | 4 | 44 | 4 | 8 | 9 | 3 | 3,018 | | **286** |
| | Entero | 16 | 2 | 3 | 3 | 24 | 30 | 5 | 31 | 8 | 3 | 234 | | **32** |
| **Jun** | Total | 38 | 14 | 38 | 17 | 21 | 78 | 8 | 45 | 4,039 | 139 | 354 | | **435** |
| **(Trace)** | Fecal | 3 | 2 | 3 | 4 | 8 | 13 | 3 | 6 | 3,002 | 5 | 16 | | **278** |
| | Entero | 6 | 2 | 4 | 4 | 9 | 21 | 3 | 2 | 3,002 | 5 | 14 | | **279** |
| **Jul** | Total | 103 | 70 | 66 | 52 | 32 | 41 | 31 | 45 | 31 | 15 | | | **49** |
| **(0.0)** | Fecal | 9 | 3 | 9 | 3 | 4 | 7 | 3 | 26 | 12 | 4 | | | **8** |
| | Entero | 48 | 4 | 4 | 6 | 6 | 13 | 5 | 92 | 14 | 4 | | | **20** |
| **Aug** | Total | 50 | 40 | 240 | 388 | 318 | 371 | 217 | 829 | 297 | 4,283 | | 1,280 | **755** |
| **(Trace)** | Fecal | 8 | 4 | 16 | 4 | 4 | 14 | 7 | 30 | 8 | 179 | | 19 | **26** |
| | Entero | 19 | 6 | 35 | 8 | 13 | 33 | 10 | 58 | 9 | 169 | | 29 | **35** |
| **Sept** | Total | 39 | 50 | 28 | 22 | 42 | 11 | 10 | 52 | 15 | 23 | | 117 | **37** |
| **(0.3)** | Fecal | 8 | 5 | 6 | 3 | 6 | 5 | 3 | 17 | 4 | 4 | | 5 | **6** |
| | Entero | 10 | 5 | 20 | 3 | 6 | 17 | 4 | 30 | 32 | 2 | | 8 | **12** |
| **Oct** | Total | 32 | 32 | 64 | 62 | 31 | 26 | 122 | 1,102 | 3,281 | 3,270 | | 2,242 | **933** |
| **(0.0)** | Fecal | 3 | 16 | 14 | 8 | 2 | 35 | 20 | 73 | 404 | 431 | | 74 | **98** |
| | Entero | 3 | 14 | 16 | 13 | 7 | 350 | 12 | 165 | 118 | 53 | | 24 | **70** |
| **Nov** | Total | 52 | 52 | 3 | 204 | 364 | 428 | 151 | 122 | 357 | 489 | | 661 | **262** |
| **(0.3)** | Fecal | 11 | 4 | 3 | 27 | 36 | 40 | 4 | 36 | 153 | 18 | | 36 | **33** |
| | Entero | 4 | 16 | 3 | 40 | 236 | 9 | 9 | 574 | 202 | 20 | | 62 | **107** |
| **Dec** | Total | 40 | 15 | 16 | 615 | 2,772 | 8,243 | 11,429 | 11,004 | 77 | 219 | | 6,175 | **3,691** |
| **(2.0)** | Fecal | 15 | 11 | 4 | 9 | 16 | 2,865 | 2,411 | 2,168 | 13 | 29 | | 45 | **690** |
| | Entero | 14 | 6 | 14 | 19 | 39 | 2,282 | 1,359 | 687 | 18 | 83 | | 133 | **423** |
| **Annual** | **Total** | **330** | **28** | **58** | **182** | **732** | **3,102** | **2,914** | **2,459** | **1,243** | **1,261** | **2,253** | **1,931** | |
| | **Fecal** | **33** | **5** | **10** | **12** | **22** | **1,084** | **536** | **378** | **334** | **115** | **663** | **38** | |
| | **Entero** | **14** | **8** | **17** | **12** | **30** | **738** | **179** | **164** | **294** | **61** | **73** | **46** | |

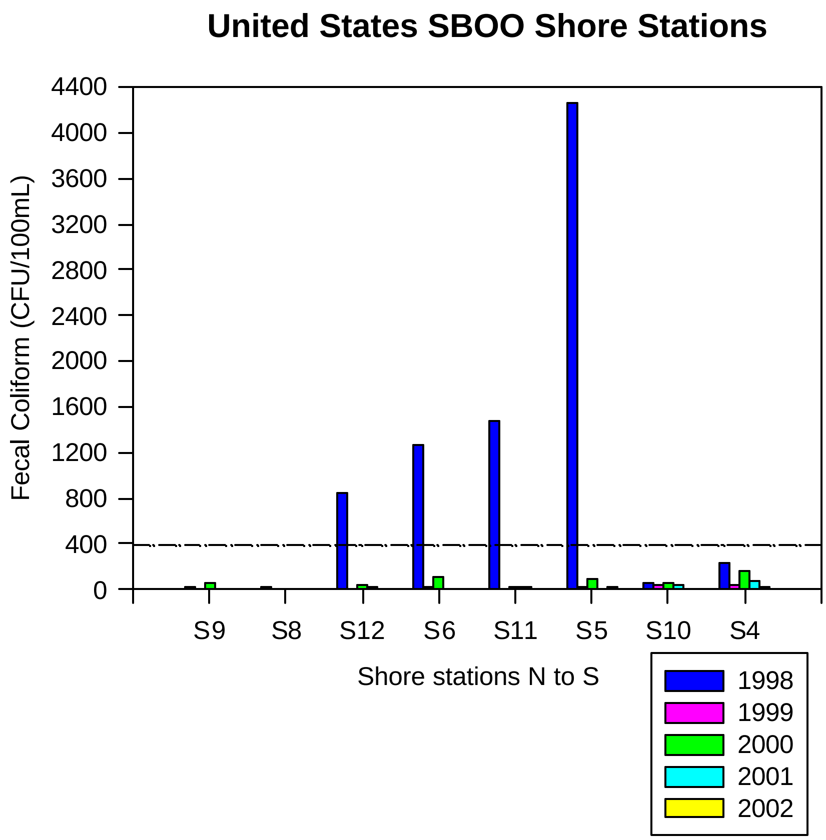



**Figure 3.3**
Average annual fecal coliform concentration for each SBOO shore station from 1998 - 2002.

greater were selected for this analysis (see California Department of Health Services, 1999). For stations north of the international border, these "high concentration/high ratio" sampling events were always associated with rainfall events that had occurred within the preceding 72 hours. In contrast, elevated bacterial concentrations at stations S-2 and S-3, located south of the border, were never associated with rainfall. These findings suggest that runoff associated with rainfall was the likely source of most of the high bacterial concentrations along the shore in 2002.

### Spatial Variability - Shore, Kelp and Offshore stations

Typical seasonal patterns for bacterial concentrations are shown in Figure 3.4. In general, mixing of the water column allowed plume material to surface near the outfall in winter, while thermal stratification during the summer months restricted the plume to mid- and deep-water depths. The plots also suggest that while some high concentrations of bacteria were influenced by the discharge plume, others were likely influenced by different sources.

## Table 3.3

Relationship between rainfall and elevated coliform counts during 2002 at SBOO shore stations.

| Station | Date | [Total Coliforms] | [Fecal]/ [Totals] | Prior Rainfall |
|---|---|---|---|---|
| S2 | 1/22/2002 | 2,300 | 0.70 | N |
| S10 | 1/30/2002 | 16,000 | 0.26 | Y |
| S5 | 2/19/2002 | 16,000 | 0.75 | Y |
| S10 | 3/19/2002 | 16,000 | 0.38 | Y |
| S3 | 3/19/2002 | 16,000 | 0.11 | Y |
| S4 | 3/19/2002 | 16,000 | 0.11 | Y |
| S5 | 3/19/2002 | 16,000 | 0.75 | Y |
| S4 | 3/20/2002 | 11,000 | 0.13 | Y |
| S5 | 3/20/2002 | 16,000 | 0.75 | Y |
| S1 | 4/16/2002 | 16,000 | 0.19 | Y |
| S5 | 4/30/2002 | 16,000 | 0.21 | Y |
| S1 | 5/7/2002 | 16,000 | 0.75 | Y |
| S3 | 6/4/2002 | 16,000 | 0.75 | N |
| S2 | 10/8/2002 | 16,000 | 0.13 | N |
| S3 | 10/8/2002 | 16,000 | 0.13 | N |
| S10 | 12/17/2002 | 16,000 | 0.19 | Y |
| S4 | 12/17/2002 | 16,000 | 0.11 | Y |
| S5 | 12/17/2002 | 1,200 | 0.17 | Y |
| S10 | 12/18/2002 | 16,000 | 0.75 | Y |
| S4 | 12/18/2002 | 16,000 | 0.75 | Y |
| S5 | 12/25/2002 | 16,000 | 0.75 | Y |
| S5 | 12/31/2002 | 16,000 | 0.28 | Y |
| | | Total # of events analyzed* = | | 22 |
| | | Total # events associated with rainfall** = | | 18 |
| | | **% of events associated with rainfall =** | | **82%** |

Shaded rows highlight events not associated with rainfall

* Sampling events where the concentration of total coliforms was > 1,000 CFU/100 mL and the ratio of fecal coliforms to total coliforms > 0.1

** Prior rainfall defined as rainfall > 0.01" within the previous 72 hours

In January, when the water column was well-mixed (see Chapter 2), bacterial concentrations in the surface waters near the outfall (stations I-12 and I-16) were above 16,000 CFU/100mL. In contrast, from March 18 – 20, relatively high bacterial concentrations (e.g., > 10,000 CFU/100mL) were restricted to areas near the outfall terminus at mid-water depths and below. While moderately high bacterial values were present at offshore stations south of the outfall during March, April and May (see March plot in Figure 3.4), bacterial densities were generally ≤ 1,000 CFU/100 mL at these stations during the summer, winter, and fall months. The southern stations I-5 and I-3 only exceeded 1,000 CFU/100 mL during three sampling events.

Wind conditions may provide an explanation for this difference. During the spring, consistent southeast winds may have increased the likelihood of southerly transport of discharge waters. Another possible source was

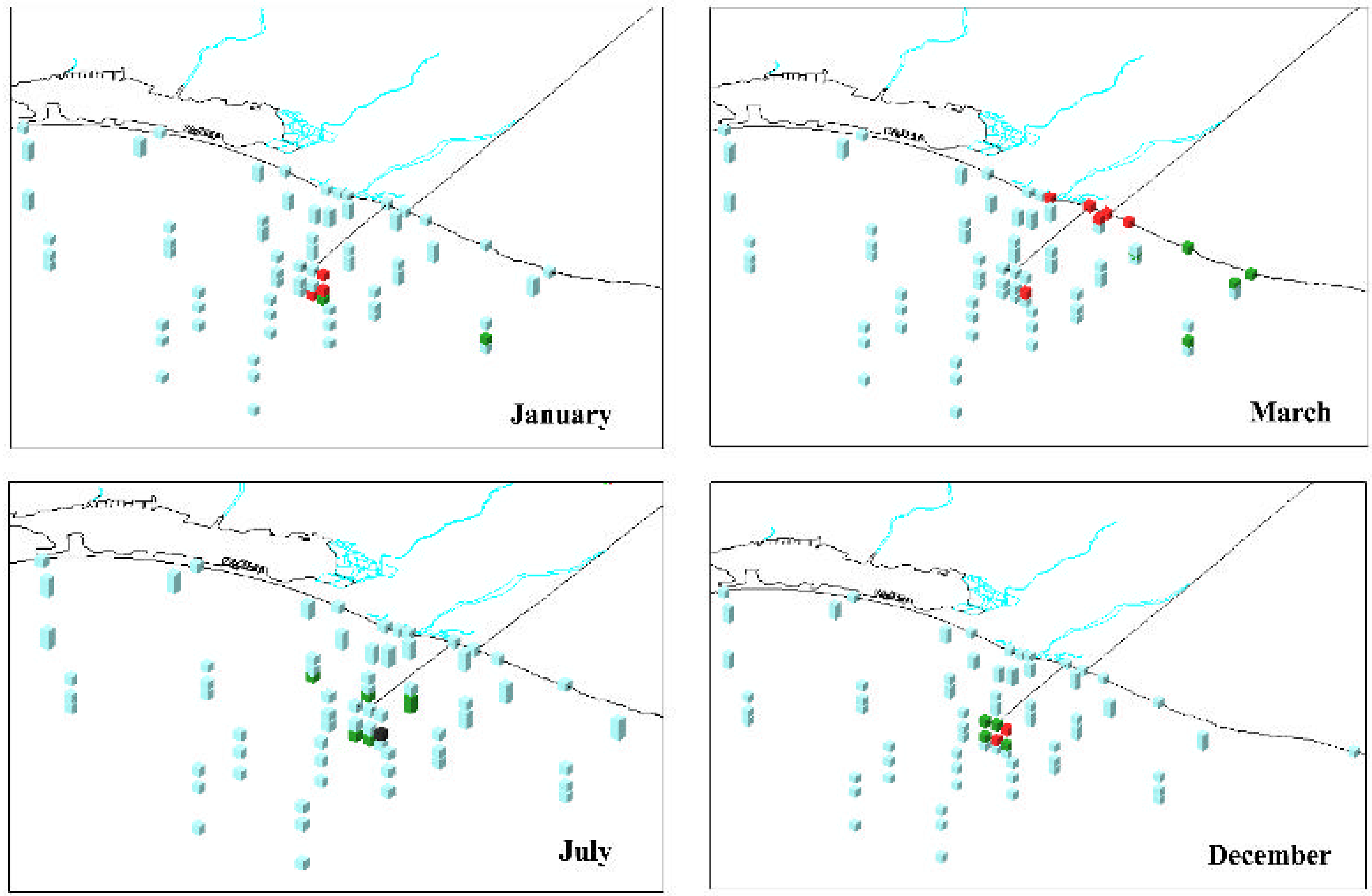



**Figure 3.4**

Volumetric plots (with deeper sample depths represented by increasingly separated stacks of blocks) illustrating total coliform concentrations for seasonally-representative monthly samples at SBOO offshore stations. The corresponding weekly shore station results are displayed as well. Abundance of total coliforms (in CFU / 100 mL) is color-coded with blue < 1,000; green > 1,000 but < 10,000; red = 10,000, and purple > 10,000.

transport of Tijuana River waters made possible by the heavy rains (0.31") and high southwest to southeast winds (from 10 – 30 mph) in March. For example, extremely high bacterial concentrations at shore stations surrounding the river mouth (S-3 – S-5 and S-10) and from the surface waters at the nearshore station I-19 followed this heavy rainfall (Figure 3.4). However, bottom waters off San Diego can flow in the opposite direction of surface waters (Dailey, et al., 1993), and contaminated waters from the south may also have been responsible for these elevated bacterial densities.

The relatively warm and calm conditions that existed from May through October appeared to affect water quality conditions in the region. For example, bacteriological data collected in July indicate that the wastewater plume remained offshore at depths below 12 m (Figure 3.4). This pattern of restricted bacterial distributions was likely due to thermal stratification (See Chapter 2). The low bacterial concentrations present

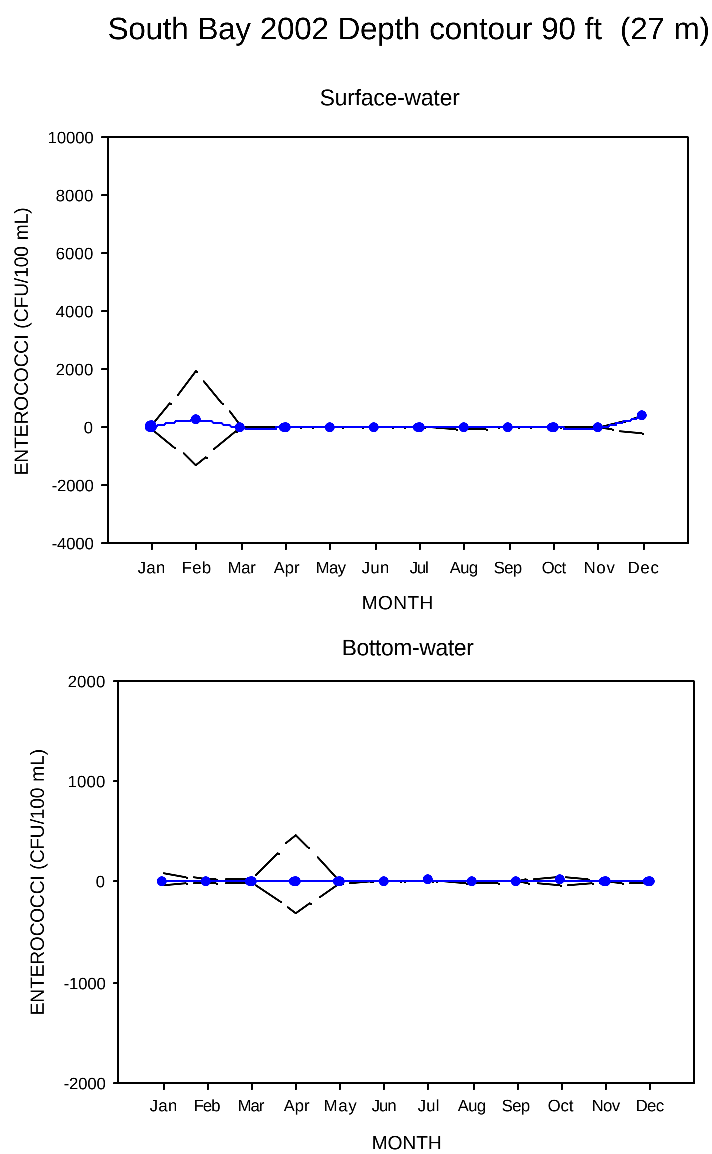



**Figure 3.5**

Average enterococcus concentrations (CFU / 100 mL) and standard deviations (as an indication of variability) at SBOO stations along the 27 m contour for surface waters and bottom waters during 2002.

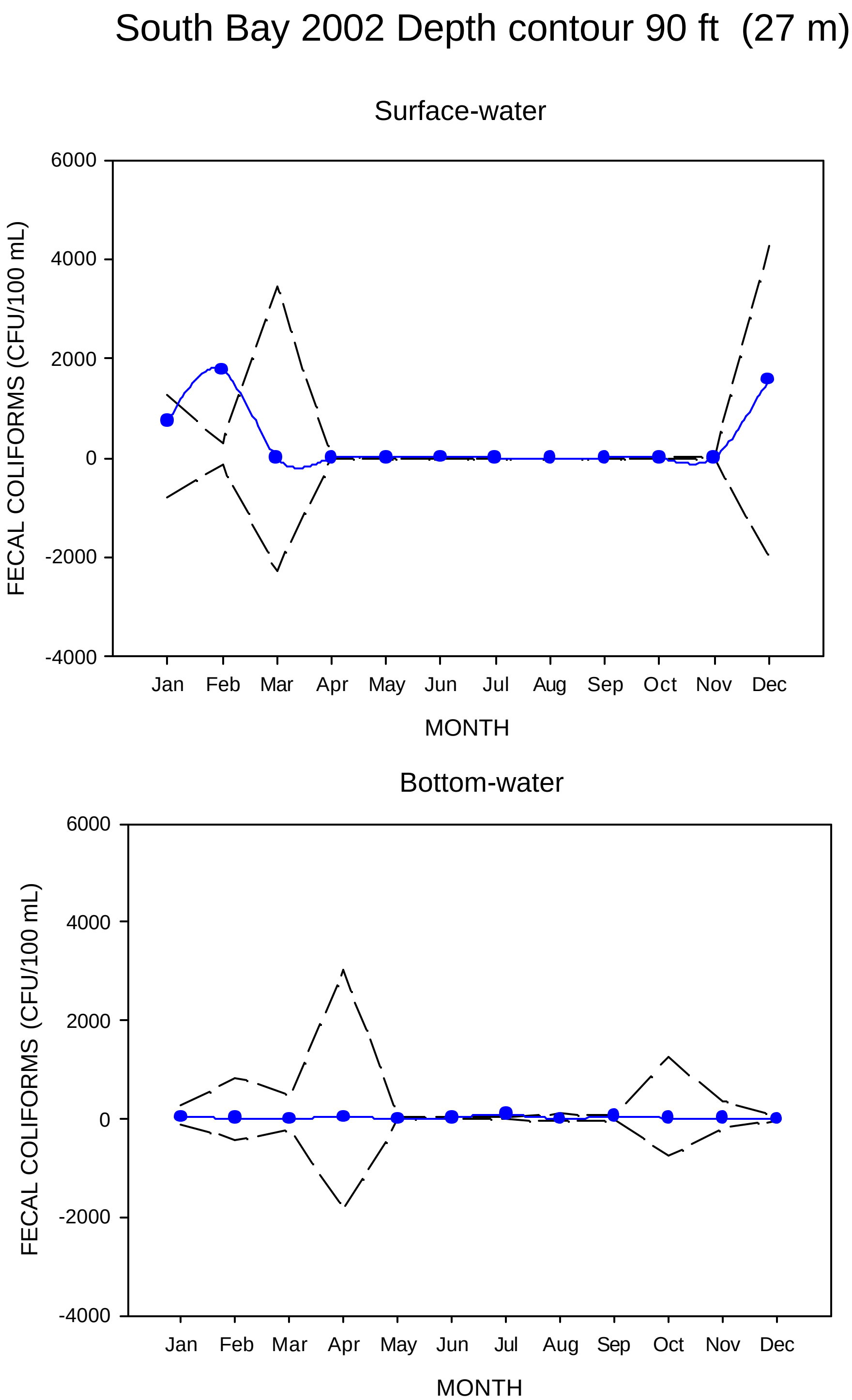



**Figure 3.6**
Average fecal coliform concentrations (CFU / 100 mL) and standard deviations (as an indication of variability) at SBOO stations along the 27 m contour for surface waters and bottom waters during 2002.

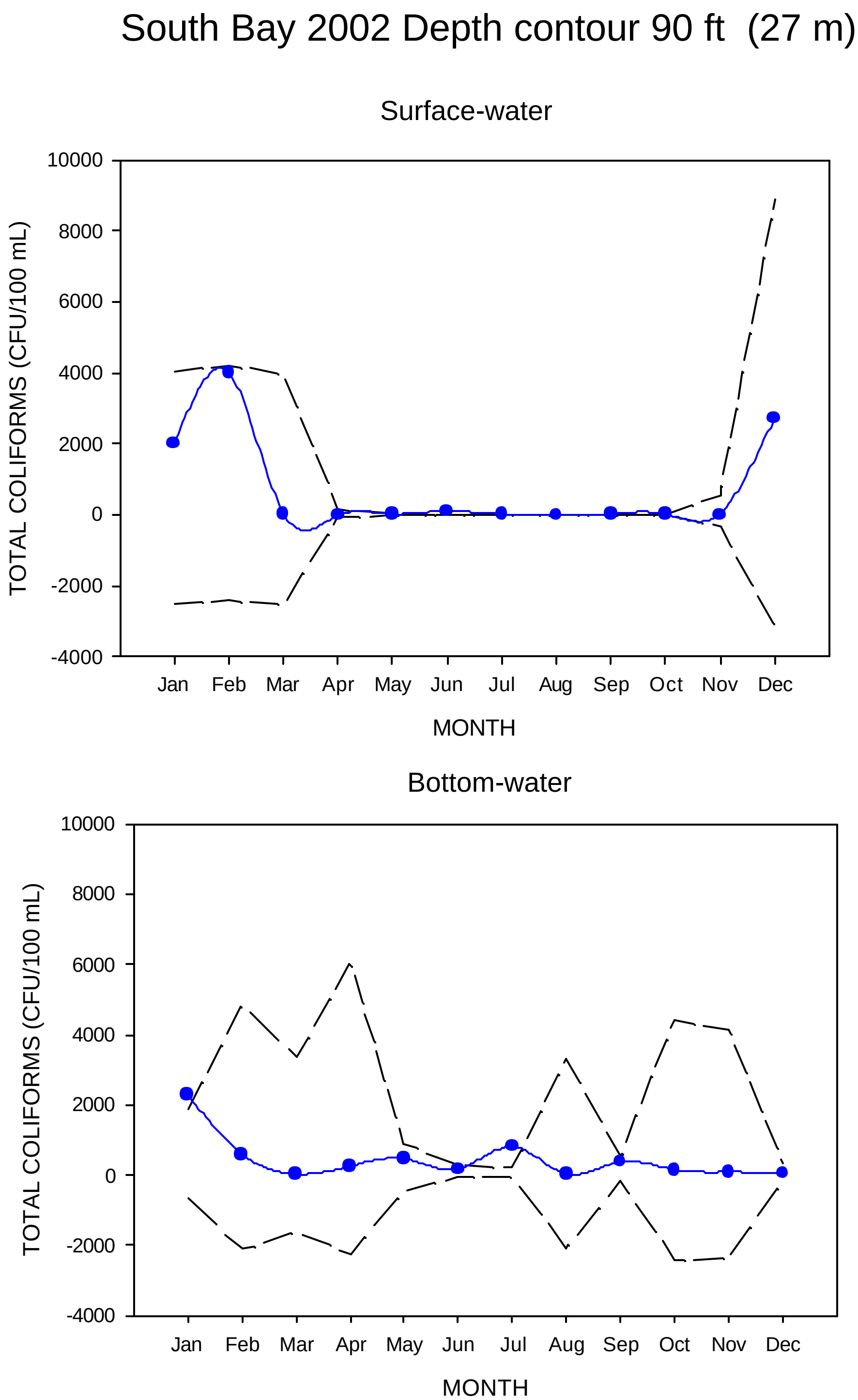



**Figure 3.7**

Average total coliform concentrations (CFU / 100 mL) and standard deviations (as an indication of variability) at SBOO stations along the 27 m contour for surface waters and bottom waters during 2002.

**Table 3.4**

Average monthly means for Total Suspended Solids (TSS) and Oil & Grease (O/G) at 2 m depth for each SBOO offshore station during 2002.

| | Monthly Means | |
|---|---|---|
| | TSS | O/G |
| January | 7.7 | < 0.2 |
| February | 6.1 | < 0.2 |
| March | 6.9 | < 0.2 |
| April | 4.7 | < 0.2 |
| May | 6.7 | < 0.2 |
| June | 6.0 | < 0.2 |
| July | 6.0 | < 0.2 |
| August | 6.4 | < 0.2 |
| September | 9.1 | < 0.2 |
| October | 6.1 | < 0.2 |
| November | 4.0 | < 0.2 |
| December | 3.6 | < 0.2 |

along the shore during this time period are consistent with what would be expected during these dry weather conditions (see Table 3.2). There were only five instances when total coliform concentrations exceeded 10,000 CFU/100mL during these months, compared to 33 instances during the remainder of the year.

### Spatial (depth) Variability - Offshore Stations

Densities of enterococcus, fecal coliforms and total coliforms were generally lower in surface waters than in bottom waters at offshore stations along the 27-m depth contour (Figures 3.5, 3.6 and 3.7). While enterococcus values were very low throughout the year, with little variability in both surface and bottom waters (Figure 3.5), more prominent seasonal patterns were evident for the fecal coliform concentrations (Figure 3.6). In both surface waters and bottom waters, as expected, the fecal coliform concentrations were high as well as highly variable during winter, spring and fall. A similar pattern was present for total coliforms in surface waters, but the bottom waters were more variable throughout most of the year (Figure 3.7).

### Bacterial Patterns and Other Indicators

Oil and grease measurements were not a useful indicator of sewage contamination according to 2002 data. Monthly averages were consistently < 0.2 mg/L (Table 3.4), which is below the standard detection limit. The highest oil and grease concentration (0.57 mg/L) was recorded on October 3 at station I-13, located 3 km west of the outfall main terminus, while high bacterial concentrations on that day were restricted to stations directly above the outfall diffusers. All other stations had enterococcus and fecal coliforms concentrations < 10 CFU/100 mL, and total coliform concentrations < 200 CFU/100 mL. Visual observations from that day also indicated calm, clear waters with no indication of the presence of the wastewater plume.

Concentrations of total suspended solids (TSS) results were variable and did not correlate with bacterial concentrations ($r^2$ = 0.05) or with chlorophyll data ($r^2$ = 0.1). For example, the highest TSS concentrations occurred in September when waters near the outfall terminus (I-14) and offshore of Coronado (I-32 and I-36) ranged from 11.5 to 23.2 mg/L. Over the same period, TSS levels in surface waters at I-19, just offshore of the Tijuana River delta reached 24.7 mg/L. Taken together, these results suggest multiple sources of total suspended solids (e.g., resuspended bottom sediments, discharged material, and terrestrial runoff) and limit the utility of high suspended solids concentrations for plume detection.

## SUMMARY & CONCLUSIONS

Water quality conditions for the South Bay region were strongly influenced by the prevalence of calm weather and low rainfall throughout most of 2002. There was no evidence that the wastewater plume from the South Bay Ocean Outfall (SBOO) reached the shore. The data indicate that the plume was confined below the thermocline of a strongly-stratified water column for most of the year and dispersed rapidly whenever transported laterally. Elevated bacterial counts were evident near the surface only during the winter months when the water column was well-mixed.

For the most part, values exceeding compliance levels along the shore and, very rarely, at kelp stations, appear to have been caused by contamination from non-outfall sources. Unlike previous years, however, bacterial contamination from the Canyon San Antonio de los Buenos Creek was minimal at the southern sampling stations (see City of San Diego, 2002). In contrast, patterns of bacterial concentration, water column physical parameters and visible satellite imagery data (Appendix F) indicate that non-outfall sources were significant: contributions from the Tijuana River, San Diego Bay and non-point source stormwater runoff all had a critical impact on the water quality at shore and nearshore stations.

Overall, bacterial data demonstrated minimal, if any, impact to nearshore water quality from the SBOO discharge during 2002. Elevated bacterial densities were generally limited to offshore waters. According to data from monthly offshore sampling, discharge-influenced waters never appear farther from the outfall than station I-18. The lack of major storm activity and the presence of strong water column stratification throughout most of the year (see Chapter 2) were likely important factors in the apparent containment of the discharge field.

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# Sediment Characteristics

# Chapter 4

# Sediment Characteristics

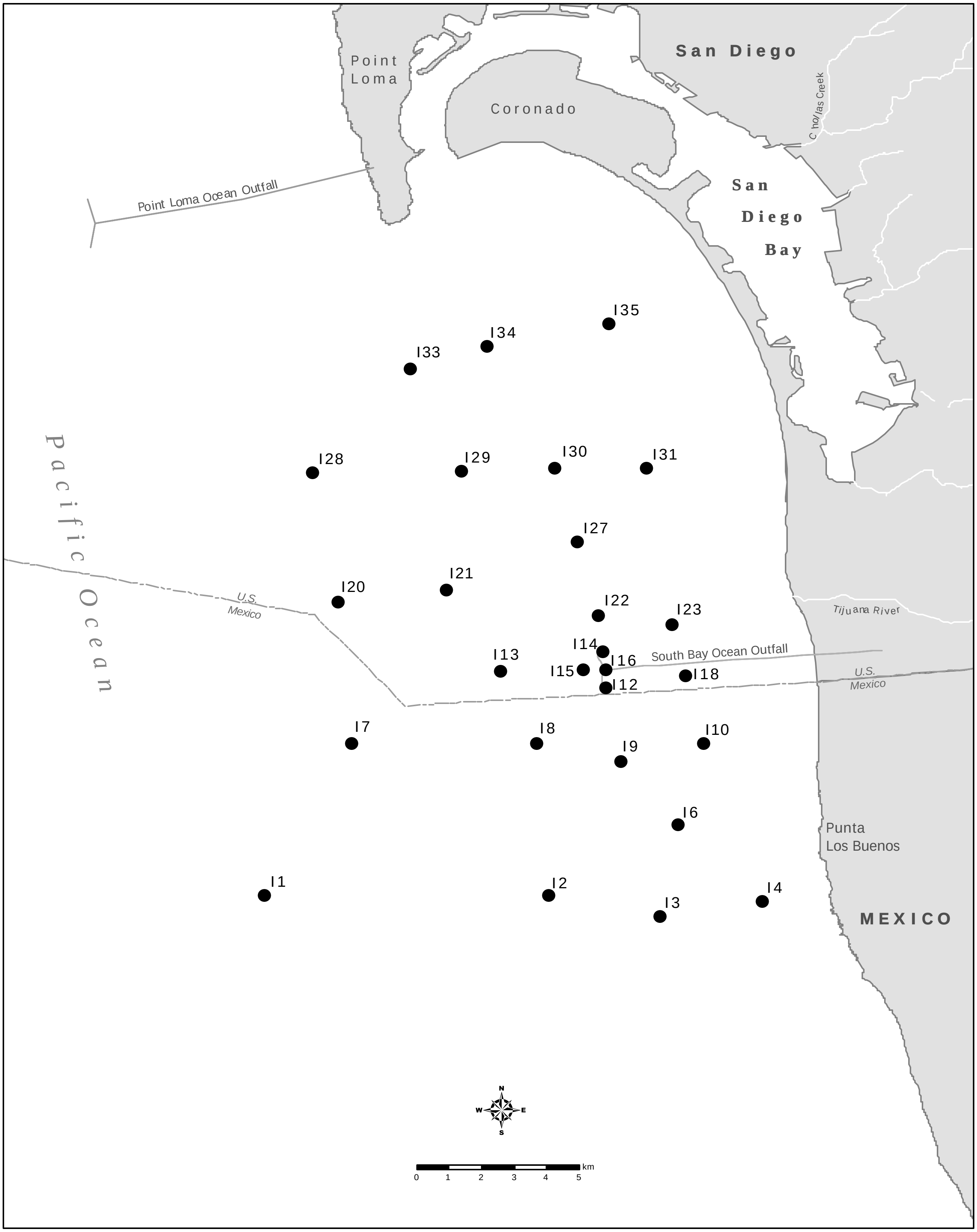
## INTRODUCTION

Sediment conditions can influence the distribution of benthic invertebrates by affecting the ability of various species to burrow, build tubes or feed (Gray 1981, Snelgrove and Butman 1994). In addition, many demersal fishes are associated with specific sediment types that reflect the habitats of their preferred prey (Cross and Allen, 1993). Both natural and anthropogenic factors affect the distribution, stability and composition of sediments. Ocean outfalls are one of many anthropogenic factors that can directly influence the composition and distribution of ocean sediments. Wastewater outfalls discharge and subsequently deposit a wide variety of organic and inorganic compounds. Among the commonly detected compounds discharged via outfalls are trace metals, pesticides and various organic compounds (e.g., organic carbon, nitrogen and sulfide compounds) (Anderson et al. 1993). Moreover, the presence of the large concrete pipe or structure can alter the hydrodynamic regime in the immediate area.

Natural factors affecting the distribution and stability of sediment grain size on the continental shelf include bottom currents, exposure to large waves, proximity to river mouths, sandy beaches, submarine basins, canyons and hills, and the presence and abundance of calcareous organisms (Emery 1960). The analysis of various parameters (e.g., sediment particle size, sorting coefficient, percentages of sand, silt and clay) can provide useful information on the amount of wave action, current velocity and sediment stability in a given area.

The chemical composition of sediments can be similarly affected by the geological history of an area. Sediment erosion from bays, cliffs, shores, and rivers and streams, contribute to the composition of metals within the area. Furthermore, deposits of red relict sands contain ferric oxide which may affect iron concentrations (Emery 1960). Finally, the organic content of sediments is greatly affected by nearshore primary productivity. This includes marine plankton production as well as terrestrial plant debris from bays, estuaries and river runoff (Mann 1982, Parsons et al. 1990). Concentrations of these materials within ocean sediments generally increase with increasing amounts of fine sediment particles chiefly as a result of adsorption (Emery 1960, Thompson et al. 1987).

This chapter presents summaries and analyses of sediment grain size and chemistry data collected during 2002 in the vicinity of the South Bay Ocean Outfall (SBOO). The major goals of the study were: (1) to assess the impact of the discharged wastewater on the benthic environment by analyzing the spatial and temporal variability of the various sediment parameters; (2) to determine the presence or absence of sedimentary and chemical footprints near the discharge site.




## Figure 4.1
Sediment chemistry station locations, South Bay Outfall Monitoring Program.

## MATERIALS & METHODS

### Field Sampling

Sediment samples were collected during January and July of 2002 at 27 stations surrounding the South Bay Ocean Outfall (Figure 4.1). These stations are located along the 19, 28, 38 and 55-m depth contours and form a grid surrounding the terminus of the outfall. A 0.1 $m^2$ chain-rigged Van Veen grab was used to collect each sample. Sub-samples for various analyses were taken from the top 2 cm of the sediment surface and handled according to EPA guidelines (USEPA 1987).

### Laboratory Analyses

All sediment analyses were performed at the City of San Diego's Wastewater Chemistry Laboratory. Particle size analysis was performed using a Horiba LA-900 laser analyzer, which measures particles ranging in size from 0 to 10 phi (i.e., sand, silt and clay fractions). Sand was defined as particles ranging in size from >0 to 4.0 phi, silt as particles from >4.0 to 8.0 phi, and clay as particles >8.0 phi. The fraction of coarser sediments (e.g., very coarse sand, gravel, shell hash) in each sample was determined by measuring the weight of particles retained on a 1.0 mm mesh sieve (i.e., 0 phi), and are expressed as the percent weight of the total sample sieved. This coarse fraction is represented as percent "Coarse" in Table 4.1 and Appendix A.1.

### Data Analyses

The following particle size parameters were calculated using a normal probability scale (see Folk 1968): mean and median phi size, sorting coefficient (standard deviation of phi size), skewness, kurtosis and percent sediment type (i.e., coarse particles > 1.0 mm in diameter, sand, silt, clay). Sediment chemical parameters that were analyzed include total organic carbon (TOC), total nitrogen, total sulfides, trace metals, chlorinated pesticides, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyl compounds (PCBs). Prior to analysis, these data were generally limited to values above method detection limits (MDLs). Some parameters, however, were determined to be present in a sample with high confidence (i.e., peaks are confirmed by mass-spectrometry), but at levels below the MDL. These were included in the data as estimated values. Null ("not detected") values were treated as zero values when performing statistics or estimating area means.

Concentrations of the various organic indicators and trace metals that were detected in the sediments of the SBOO region during 2002 were compared to the results from previous pre-discharge (1995-1998) and post-discharge (1999-2001) periods. In addition, values for metals, TOC, TN and pesticides (i.e., DDE) were compared to median values for the Southern California Bight. These bightwide values were based on the cumulative distribution function (CDF) for each parameter (see Schiff and Gossett 1998) and are presented as the 50% CDF in the tables included herein.

## RESULTS & DISCUSSION

### Particle Size Distribution

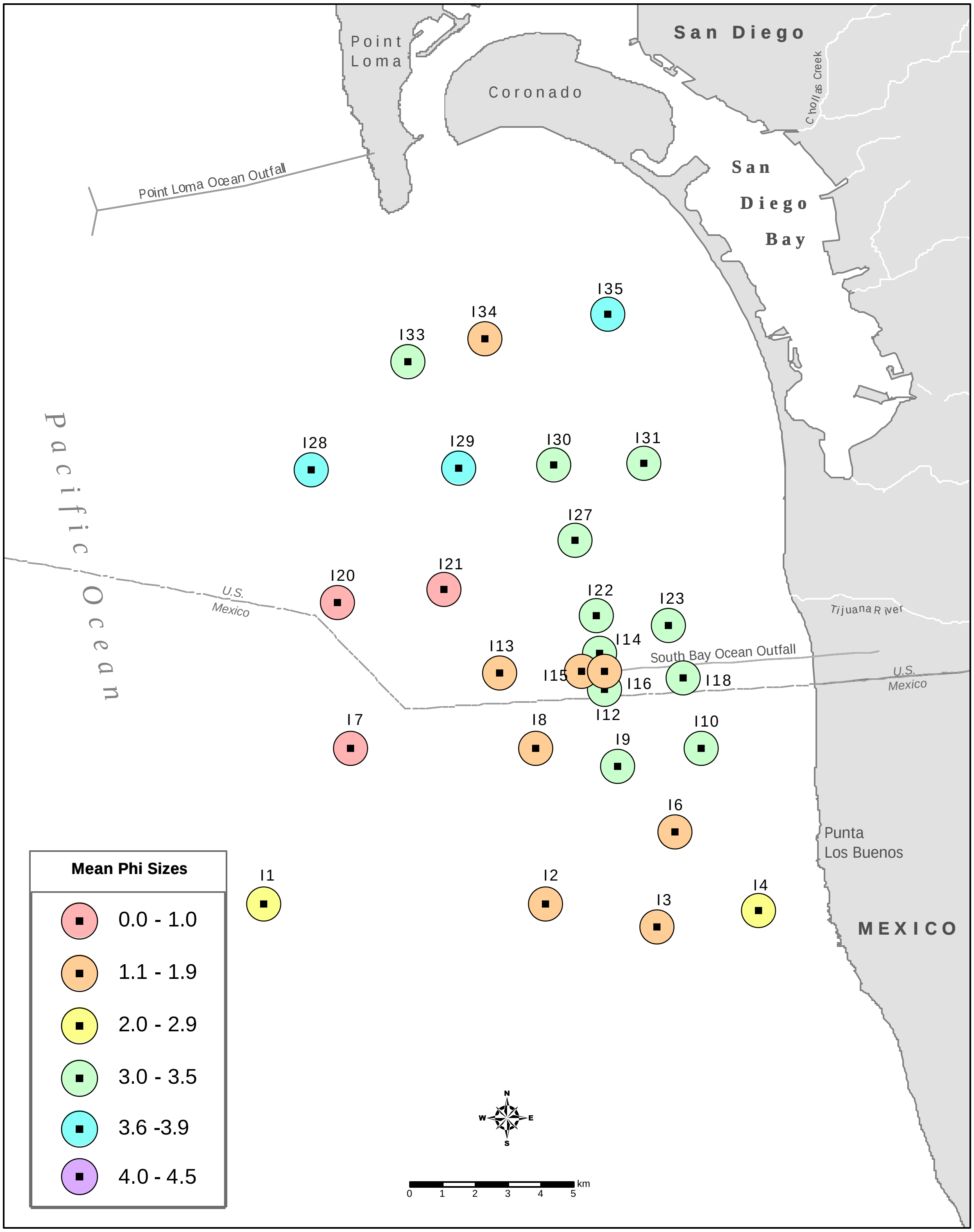
With few exceptions, fine to medium sands comprised the overall composition of sediments surrounding the South Bay Ocean Outfall (SBOO) in 2002 (Table 4.1, Figure 4.2). There appears to have been little change in mean phi size for the region since 1995. For example, particle sizes averaged 2.4 phi in 2002 and previous post-discharge years, and 2.6 phi over the 1995 -1998 pre-discharge period. There were also few differences in particle size distribution between the January and July 2002 surveys (Figure 4.3, Figure 4.4, Appendix A.1). Low sorting coefficients (standard deviation) of <1.0 phi indicate the influence of strong wave and current activity on sediment composition within the area (see Gray 1981). Stations that exhibited the greatest changes (> 1.0 phi) included I-4, I-16, and I-34.

Stations south of the SBOO were generally more coarse than those to the north (Table 4.1, Figure 4.2). Many stations offshore and southward of the SBOO consisted of very coarse sediments ($\leq$2.8 phi). The remaining stations located along the shallower 19 and 28 m contours and towards the mouth of San Diego Bay consisted of finer sediments (3.0 - 3.8 phi). The higher silt content at these stations is probably due to sediment deposition from the Tijuana River and to a lesser extent from San Diego Bay (see City of San Diego 1988). This pattern was evident even though many sites varied in proportion of shell hash, red relict sand, coarse sand and silt.

While the overall composition of the sediments surrounding the SBOO has changed little over time, two stations have been highly variable (Figure 4.5). Sediments at station I-16 have become more variable and smaller since the construction of the nearby outfall diffusers. Average particle size at this site decreased from 2.4 phi prior to discharge to 1.6 phi during the post-discharge period. This may be partially attributed to the sand ballast placed over the diffusers, and to the disturbance of sediments during the construction period. Particle size at station I-28 has also been variable over the years, ranging from 0.7 – 4.2 mean phi. This station is located near the defunct LA-4 dredged material disposal site, and has generally contained particles and toxic chemicals indicative of dredged sediments. In contrast to previous years, particle size was similar for both 2002 surveys with values of 3.8 and 4.0 phi for January and July, respectively.

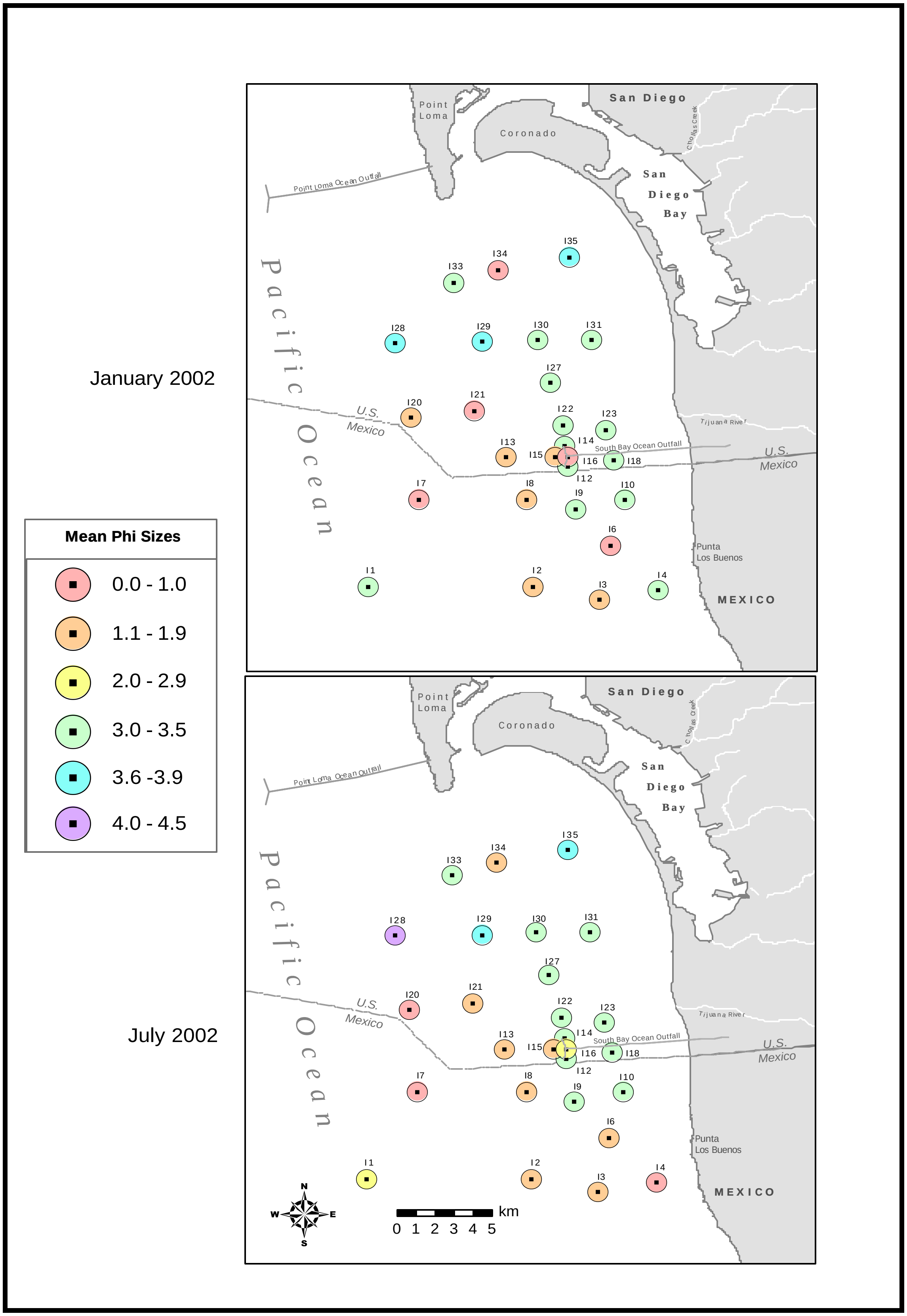
### Indicators of Organic Loading

The average concentrations of total organic carbon and total nitrogen for the SBOO area in 2002 were similar to those of previous surveys. Moreover, concentrations were mostly below the median values for the Southern California Bight (Table 4.1, Figure 4.4). The highest average values for these indicators were found at stations I-28, I-29 and I-35, and correspond to high silt concentrations at these sites (Figure 4.2). This is not unexpected, since particle size is known to be a factor affecting concentrations of organic parameters (Emery 1960, Eganhouse and Venkatesan 1993). Finally, average sulfide concentrations during the year were only slightly higher than the MDL and were considerably lower than pre- and post discharge values.




## Figure 4.2

Sediment particle size distribution based on mean phi for January and July surveys of SBOO sediment chemistry stations during 2002.




# Figure 4.3

Comparison of January and July surveys for differences in sediment particle size distribution based on mean phi for SBOO sediment chemistry stations during 2002.

## Table 4.1

Summary of sediment particle size parameters and organic compounds for SBOO sediment chemistry stations during 2002, pre-discharge (1995-1998) and post discharge (1999-2001) surveys. Particle size data were determined from a probability curve and are expressed as annual means for: (1) phi size; (2) standard deviation (SD); (3) coarse particles > 1.0 mm; (4) percent sand; (5) percent silt; (6) percent clay. The organic compounds include: (1) sulfides (parts per million); (2) total nitrogen (percentage of weight); total organic carbon (percentage of weight). Also included are method detection limits, area means and the 50% CDF value for the Southern California Bight (Schiff and Gosset 1998).

| | Mean Phi | SD Phi | Coarse % | Sand % | Silt % | Clay % | Sulfides ppm | TN WT% | TOC WT% | Sediment Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| **50%CDF** | | | | | | | **na** | 0.051 | 0.748 | |
| **MDL** | | | | | | | 0.05 | 0.001 | 0.009 | |
| ***19 m stations*** | | | | | | | | | | |
| I-35 | 3.8 | 1.1 | 0.0 | 63.0 | 35.2 | 1.7 | 1.27 | 0.027 | 0.233 | silty sand, coarse sand, tube debris |
| I-34 | 1.1 | 0.8 | 23.7 | 76.1 | 0.2 | 0.0 | 0.55 | 0.010 | 0.047 | sand, coarse sand, shell hash |
| I-31 | 3.2 | 0.6 | 0.0 | 92.8 | 6.6 | 0.4 | 0.53 | 0.013 | 0.116 | fine sand |
| I-23 | 3.2 | 0.7 | 0.0 | 89.4 | 9.8 | 0.8 | 0.55 | 0.013 | 0.102 | silty sand, shell hash |
| I-18 | 3.1 | 0.6 | 0.0 | 91.9 | 7.6 | 0.4 | 0.42 | 0.014 | 0.119 | silt |
| I-10 | 3.1 | 0.7 | 0.0 | 90.8 | 8.5 | 0.6 | 0.50 | 0.013 | 0.131 | fine sand, silt |
| I-4 | 2.0 | 0.6 | 0.0 | 94.6 | 5.0 | 0.3 | 2.32 | 0.013 | 0.112 | silty sand, shell hash |
| ***28 m stations*** | | | | | | | | | | |
| I-33 | 3.0 | 0.9 | 0.0 | 88.1 | 10.7 | 1.1 | 3.52 | 0.023 | 0.178 | silt, shell hash |
| I-30 | 3.3 | 0.9 | 0.0 | 84.3 | 14.7 | 0.9 | 1.59 | 0.023 | 0.196 | fine sand |
| I-27 | 3.2 | 0.9 | 0.0 | 85.7 | 13.5 | 0.8 | 1.18 | 0.020 | 0.184 | silty sand |
| I-22 | 3.3 | 0.8 | 0.0 | 85.9 | 13.2 | 0.8 | 1.02 | 0.019 | 0.172 | silt |
| I-14 | 3.3 | 0.6 | 0.0 | 89.8 | 9.6 | 0.5 | 0.35 | 0.019 | 0.167 | silt |
| I-15 | 1.6 | 0.6 | 0.0 | 98.9 | 1.0 | 0.0 | 0.39 | 0.009 | 0.085 | fine sand, coarse black sand |
| I-16 | 1.6 | 0.7 | 0.0 | 95.6 | 4.0 | 0.3 | 0.26 | 0.011 | 0.103 | sand, shell hash |
| I-12 | 3.2 | 0.8 | 0.8 | 87.2 | 11.1 | 0.7 | 1.06 | 0.015 | 0.157 | sand, shell hash |
| I-9 | 3.4 | 0.8 | 0.0 | 81.5 | 17.4 | 1.0 | 1.19 | 0.020 | 0.191 | sandy silt |
| I-6 | 1.2 | 0.6 | 1.8 | 97.6 | 0.4 | 0.0 | 0.27 | 0.011 | 0.059 | red relict sand, coarse sand, shell hash |
| I-2 | 1.6 | 0.6 | 0.0 | 99.4 | 0.6 | 0.0 | 0.08 | 0.008 | 0.075 | silty sand |
| I-3 | 1.5 | 0.7 | 0.0 | 99.6 | 0.3 | 0.0 | 0.00 | 0.005 | 0.074 | red relict sand, coarse sand, shell hash |
| ***38 m stations*** | | | | | | | | | | |
| I-29 | 3.7 | 1.0 | 0.0 | 67.5 | 30.6 | 1.8 | 1.80 | 0.031 | 0.299 | fine, red relict and black sand, shell hash |
| I-21 | 1.0 | 0.7 | 7.5 | 92.3 | 0.1 | 0.0 | 0.02 | 0.011 | 0.105 | red relict sand |
| I-13 | 1.2 | 0.6 | 0.4 | 99.9 | 0.0 | 0.0 | 0.75 | 0.011 | 0.092 | red relict sand, clay, shell hash |
| I-8 | 1.3 | 0.6 | 0.0 | 99.8 | 0.2 | 0.0 | 0.00 | 0.012 | 0.094 | sand |
| ***55 m stations*** | | | | | | | | | | |
| I-28 | 3.9 | 2.1 | 10.1 | 51.0 | 34.8 | 3.9 | 0.85 | 0.031 | 0.279 | coarse sand w/silt, coarse black sand |
| I-20 | 1.0 | 0.9 | 12.9 | 86.9 | 0.0 | 0.0 | 0.54 | 0.012 | 0.097 | red relict sand, coarse sand |
| I-7 | 1.0 | 0.6 | 4.4 | 95.4 | 0.3 | 0.0 | 0.02 | 0.010 | 0.074 | red relict sand |
| I-1 | 2.8 | 0.9 | 0.0 | 88.9 | 10.0 | 1.0 | 0.15 | 0.022 | 0.194 | silty sand |
| **Area Means** | | | | | | | | | | |
| **2002** | 2.4 | 0.8 | 2.3 | 90.2 | 9.1 | 0.6 | 0.79 | 0.016 | 0.139 | |
| **Post-** | 2.4 | 0.8 | 1.1 | 90.1 | 8.1 | 0.6 | 2.54 | 0.018 | 0.136 | |
| **Pre-** | 2.6 | 1.1 | 1.4 | 87.7 | 9.5 | 0.8 | 4.59 | 0.019 | 0.143 | |

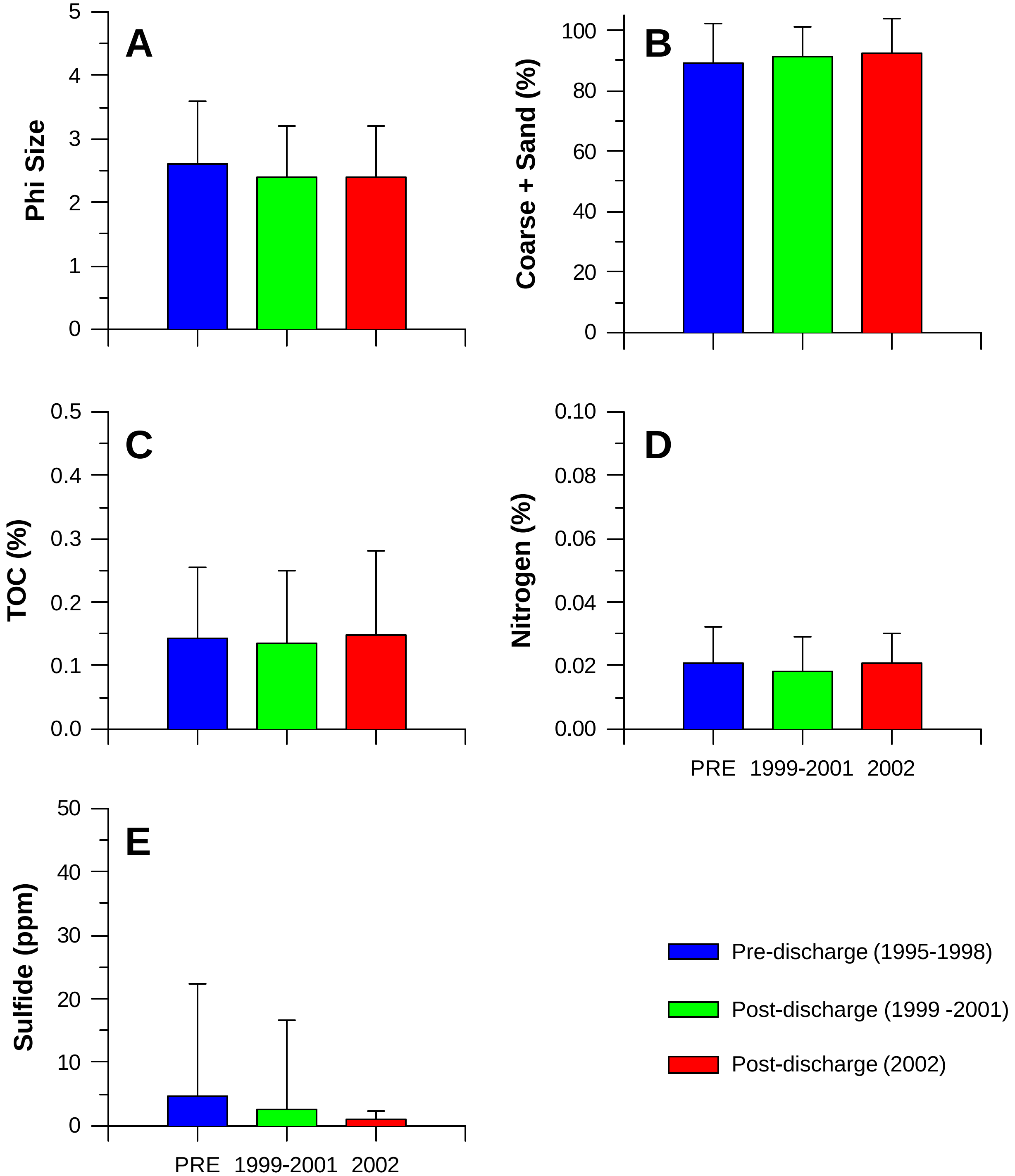



**Figure 4.4**

Comparison of values for several sediment quality parameters surrounding the SBOO in 2002 with values during the first three years of post-discharge monitoring (1999-2001) and the pre-discharge period (1995-1998): (A) mean phi size; (B) percent coarse and sand; (C) percent total organic carbon; (D) percent total nitrogen; (E) sulfides (ppm). Data are expressed as area wide means for each survey period. Error bars represent one standard deviation.

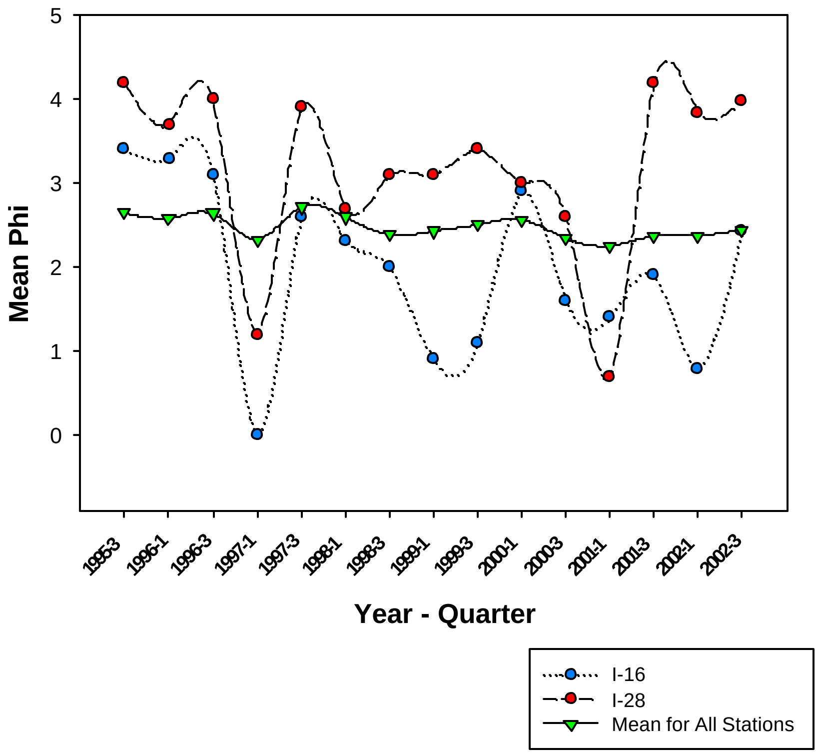



**Figure 4.5**

Comparison of mean phi values for stations I16, I28 and all stations combined for all SBOO surveys during the period of July 1995 through July 2002.

## Trace Metals

Trace metal concentrations in the SBOO sediments were generally low compared to the median values for southern California (Table 4.2). Only aluminum, arsenic, chromium, copper, iron, manganese and zinc were detected at all or nearly all stations. Stations I-35 and I-9 had relatively higher concentrations of these metals, which corresponded to the finer particles at these two stations. In contrast, arsenic occurred in high concentrations where sediments consisted of very coarse red relict sand (i.e., stations I-21, I-7 and I-13). Many trace metals, however, were detected at concentrations near or below their MDLs. Several others, such as antimony, lead, silver and tin were not detected at all, while beryllium, cadmium, mercury, nickel, selenium and thallium were detected infrequently.

## Pesticides

Chlorinated pesticides were detected in only three sediment samples collected in 2002. These consisted of one DDT derivative (p,p-DDE). This derivative was detected at concentrations of 2,100 and 1,800 parts per trillion (ppt) at stations I-28 and I-29, respectively in January, and at concentrations of 470 ppt at station I-29 in July. The values detected during January were higher than the median value of 1,250 for this pesticide. Both sites contained black sand, which has been periodically associated with dredge disposal materials (see City of San Diego 2001, 2002a, 2002b). For example, coarse black sand has also been found at stations near the construction areas of the Point Loma and South Bay outfalls where dredging and deposition of ballast sand occurred and at Point Loma outfall stations located near the LA-5 dredge disposal site.

## Table 4.2

Concentrations of metals (parts per million) for each station during 2002, pre-discharge (1995-1998) and post-discharge (1999-2001) surveys. Data for metals include: aluminum (Al); arsenic (As); beryllium (Be); cadmium (Cd); chromium (Cr); copper (Cu); iron (Fe); manganese (Mn); mercury (Hg); nickel (Ni); selenium (Se); thallium Tl); and zinc (Zn). Values below detection limits are designated by “nd”. Also included are area means, method detection limits (MDL), and the 50% CDF value for the Southern California Bight (Schiff and Gosset 1998). Values that exceed the 50% CDF are indicated in bold type. ** = not available

| | Al | As | Be | Cd | Cr | Cu | Fe | Mn | Hg | Ni | Se | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MDL** | 5 | 0.08 | 0.20 | 0.5 | 3 | 2 | 3 | 0.5 | 0.03 | 3.0 | 0.11 | 10 | 4 |
| **50% CDF** | 9400 | 4.8 | 0.26 | 0.29 | 34 | 12 | 16800 | ** | 0.04 | ** | 0.29 | ** | 56 |
| *19 m stations* | | | | | | | | | | | | | |
| I-35 | 9060 | 2.70 | nd | nd | 13.5 | 6.2 | 10225 | 103.6 | 0.010 | 2.3 | 0.06 | nd | 23 |
| I-34 | 1960 | 1.79 | nd | nd | 4.0 | 2.3 | 3105 | 26.8 | 0.006 | nd | nd | nd | 4 |
| I-31 | 4100 | 1.13 | **0.51** | nd | 7.5 | 1.4 | 3850 | 50.4 | 0.003 | nd | nd | 6 | 7 |
| I-23 | 5045 | 1.52 | nd | nd | 8.5 | 3.5 | 4890 | 55.8 | 0.002 | nd | nd | nd | 9 |
| I-18 | 5760 | 1.58 | nd | nd | 11.0 | 3.1 | 6400 | 65.0 | nd | nd | nd | nd | 11 |
| I-10 | 6825 | 1.63 | nd | nd | 11.2 | 4.8 | 6950 | 72.3 | nd | nd | 0.08 | nd | 13 |
| I-4 | 5165 | 1.33 | nd | nd | 9.5 | 1.5 | 5420 | 63.6 | nd | nd | 0.06 | nd | 15 |
| *28 m stations* | | | | | | | | | | | | | |
| I-33 | 5420 | 2.03 | nd | nd | 8.5 | 4.6 | 5955 | 70.3 | 0.010 | nd | 0.07 | nd | 19 |
| I-30 | 7190 | 2.02 | nd | nd | 10.3 | 4.5 | 6310 | 64.5 | 0.005 | nd | nd | nd | 13 |
| I-27 | 6545 | 1.44 | **0.60** | nd | 10.3 | 1.8 | 6510 | 64.3 | 0.005 | 1.8 | nd | nd | 13 |
| I-22 | 6190 | 1.88 | nd | nd | 10.6 | 2.5 | 6010 | 63.6 | nd | nd | nd | nd | 12 |
| I-14 | 7395 | 1.84 | nd | nd | 11.5 | 3.9 | 7630 | 77.6 | nd | nd | nd | nd | 18 |
| I-16 | 4095 | 1.53 | nd | nd | 7.3 | 8.3 | 4765 | 45.9 | 0.002 | nd | nd | nd | 10 |
| I-15 | 2815 | 2.34 | nd | nd | 8.8 | 10.6 | 4235 | 28.0 | 0.002 | nd | nd | nd | 36 |
| I-12 | 7400 | 1.79 | nd | **0.43** | 10.6 | 7.3 | 6940 | 72.4 | nd | 1.6 | 0.10 | nd | 15 |
| I-9 | **9450** | 1.48 | nd | nd | 13.1 | 8.6 | 8435 | 87.6 | nd | 4.0 | 0.06 | nd | 20 |
| I-6 | 1861 | 4.35 | nd | nd | 7.0 | 7.3 | 3990 | 22.5 | nd | nd | nd | nd | 4 |
| I-2 | 1425 | 0.75 | nd | nd | 5.9 | 2.8 | 1335 | 13.1 | nd | nd | 0.21 | nd | nd |
| I-3 | 1004 | 1.08 | nd | nd | 5.9 | 1.3 | 1315 | 9.6 | nd | nd | nd | nd | nd |
| *38 m stations* | | | | | | | | | | | | | |
| I-29 | 8125 | 2.34 | nd | nd | 12.7 | 5.3 | 8545 | 75.4 | 0.008 | 4.3 | nd | nd | 18 |
| I-21 | 1340 | **9.71** | nd | nd | 11.3 | 5.5 | 7765 | 14.6 | nd | nd | nd | nd | 3 |
| I-13 | 1655 | **4.87** | nd | **0.32** | 9.7 | 4.6 | 4960 | 21.2 | nd | nd | 0.07 | nd | 3 |
| I-8 | 1740 | 2.35 | nd | nd | 8.2 | 3.7 | 3690 | 16.5 | 0.001 | nd | 0.08 | nd | 6 |
| *55 m stations* | | | | | | | | | | | | | |
| I-28 | 7470 | 2.32 | **0.52** | nd | 11.7 | 8.5 | 8265 | 65.7 | 0.020 | 2.8 | 0.09 | nd | 17 |
| I-20 | 1330 | 2.92 | nd | nd | 4.9 | 1.8 | 4615 | 15.7 | nd | nd | nd | nd | 3 |
| I-7 | 1340 | **6.06** | nd | nd | 9.0 | 1.1 | 6035 | 16.8 | nd | nd | 0.06 | nd | 3 |
| I-1 | 2935 | 1.17 | nd | nd | 7.2 | 2.2 | 3415 | 33.4 | 0.002 | nd | 0.09 | nd | 7 |
| **Area Means** | | | | | | | | | | | | | |
| 2002 | 4616 | 2.44 | 0.06 | 0.03 | 9.3 | 4.4 | 5613 | 48.8 | 0.003 | 0.6 | 0.04 | 0.2 | 11 |
| Post- | 4808 | 2.44 | 0.18 | 0.08 | 8.7 | 4.4 | 6068 | 56.1 | 0.001 | 1.3 | 0.02 | 0.6 | 14 |
| Pre- | 5164 | 2.47 | 0.12 | 0.00 | 10.2 | 2.6 | 6568 | 47.4 | 0.003 | 0.2 | 0.07 | 0.2 | 13 |

## PCB and PAH

Polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) were found at low levels during the July 2002 survey only. Moreover, all concentrations were near or below MDL levels, and should therefore be viewed with caution. PCB 101 and PCB 110 occurred at station I-28, located near the defunct LA-4 dredge disposal site. The concentrations of these two congeners (870 and 650 ppt, respectively) were well below the MDLs of 2,600 ppt for PCB 101 and 2,900 ppt for PCB 110. In contrast, eight PAHs were detected at two stations well away from the dredge disposal sites (Appendix A.2). Of these, station I-1 (55 m) is located in Mexican waters, and station I-35 (19-m) is near the mouth of San Diego Bay. Both stations had sediments consisting of silty sand.

## SUMMARY & CONCLUSIONS

The sediments surrounding the South Bay Ocean Outfall (SBOO) in 2002 consisted primarily of fine to medium sands with an average particle size of 2.4 phi. The variability in sediment composition between stations may be partially attributed to the multiple geological origins of red relict sands, shell hash, coarse sands, and other detrital sediments (Emery 1960). Stations located offshore and southward of the SBOO consisted of very coarse sediments. In contrast, stations located in shallower water and north of the outfall towards the mouth of San Diego Bay had finer sediments. Sediment deposition from the Tijuana River and to a lesser extent from San Diego Bay probably contribute to the higher content of silt at these stations (see City of San Diego 1988).

Concentrations of organic indicators and metals were relatively low in sediments from the SBOO area compared to the entire southern California continental shelf (see Schiff and Gossett 1998). Higher concentrations of organic compounds and most trace metals were generally associated with finer sediments. This pattern is consistent with that found in other studies, in which the accumulation of fine sediments has been shown to greatly influence the organic and metal content of sediments (e.g., Eganhouse and Venkatesan 1993). Only aluminum, arsenic, chromium, copper, iron, manganese and zinc were detected at all or nearly all stations. Stations I-35 and I-9 had relatively high concentrations of these metals, and both had higher percentages of fine sediments in comparison to other stations. In contrast, the uppermost concentrations of arsenic were found where sediments consisted of very coarse red relict sand.

Other sediment contaminants were rarely detected in the region during 2002. One derivative of the chlorinated pesticide DDT was detected at two stations with coarse black sand, while PCB compounds were detected at a single station. Eight polycyclic aromatic hydrocarbons were found at two stations during July.

Overall, sediment conditions surrounding the South Bay Ocean Outfall in 2002 were similar to previous years (see City of San Diego 2002a). Furthermore, there was no indication of contaminant footprints surrounding the South Bay outfall based on analyses of particle size or sediment chemistry data.

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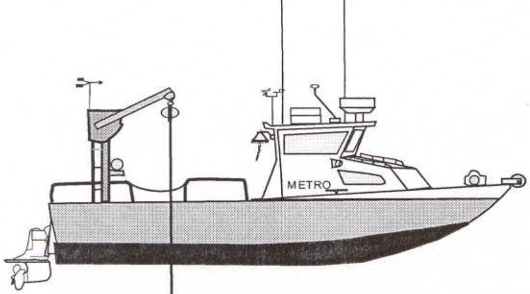
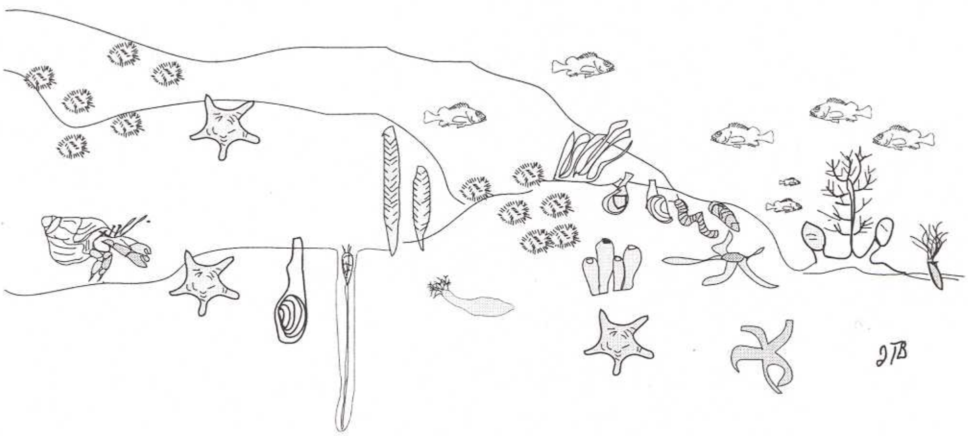



# Benthic Infauna



# Chapter 5

# Benthic Infauna

## INTRODUCTION

Marine sediments on the southern California coastal shelf typically contain a diverse community of infaunal invertebrates (Fauchald and Jones 1979, Thompson et al. 1993a, Bergen et al. 2001). These animals are essential members of the marine ecosystem, serving vital functions in wide ranging capacities. For example, many infaunal species provide the prey base for fish and other organisms, while others decompose organic material as a crucial step in nutrient cycling.

Living in the sediments, however, puts these animals in direct contact with the toxic contaminants and low oxygen conditions that can be associated with human impacts. Since benthic infauna have limited mobility, they are generally not able to avoid such adverse conditions. In addition, because various species respond differently to environmental stress, infaunal assemblages have become valuable indicators of anthropogenic impact (Pearson and Rosenberg 1978). Consequently, the assessment of benthic community structure is a major component of many marine monitoring programs, which document both existing conditions and trends over time.

The structure of infaunal communities is influenced by many factors including sediment conditions (e.g., particle size and sediment chemistry), water conditions (e.g., temperature, salinity, dissolved oxygen and current velocity) and biological factors (e.g., food availability, competition and predation). Although human activities can affect these factors, natural processes largely control the structure of invertebrate communities in marine sediments. For example, benthic assemblages in the region surrounding the South Bay Ocean Outfall (SBOO), typically vary along natural gradients in particle size and depth. Therefore, in order to determine whether changes in community structure are related to human impacts or natural processes, it is necessary to have documentation of background or reference conditions for an area. Such information is available for the SBOO discharge area (City of San Diego 2000) and the San Diego region in general (e.g., City of San Diego 1999).

This chapter presents analyses and interpretations of the infaunal data collected at fixed stations surrounding the SBOO during 2002. Included are descriptions and comparisons of soft-bottom infaunal assemblages in the area, and analysis of benthic community structure.

## MATERIALS & METHODS

### Collection and Processing of Samples

Benthic samples were collected during January and July 2002 at 27 stations surrounding the SBOO pipe (Figure 5.1). These stations range in depth from 18 to 60 m along four depth contours. Stations listed from north to south

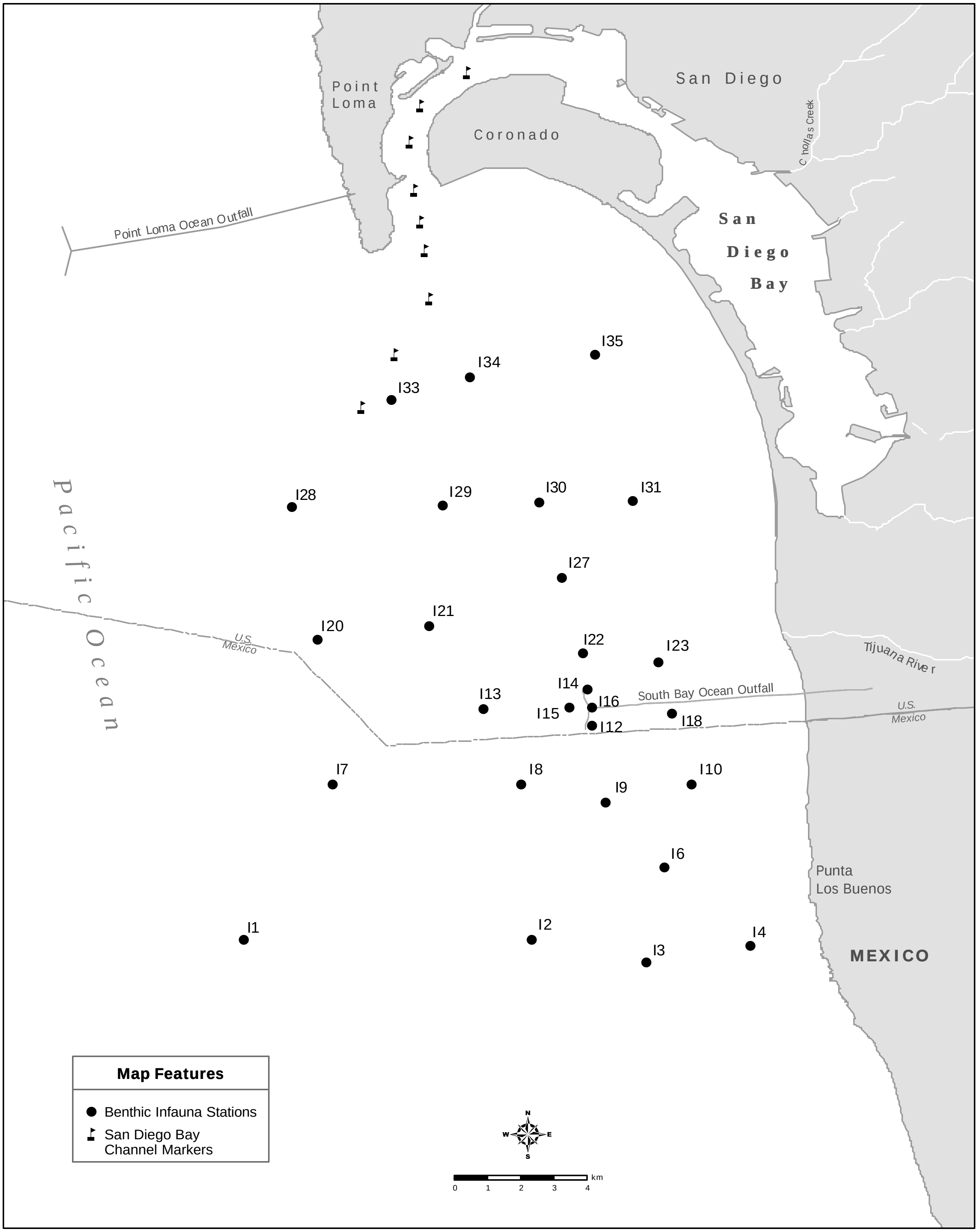



**Figure 5.1**
Benthic infauna station locations, South Bay Ocean Outfall Monitoring Program.

along each contour include: (1) 19-m contour, stations I-35, I-34, I-31, I-23, I-18, I-10, I-4; (2) 28-m contour, stations I-33, I-30, I-27, I-22, I-14, I-16, I-15, I-12, I-9, I-6, I-2, I-3; (3) 38-m contour, stations I-29, I-21, I-13, I-8; (4) 55-m contour, stations I-28, I-20, I-7, I-1.

Samples for benthic community analysis were collected from two replicate 0.1-$m^2$ van Veen grabs per station during each survey. The criteria established by the United States Environmental Protection Agency (USEPA) to ensure consistency of grab samples were followed with regard to sample disturbance and depth of penetration (USEPA 1987). All samples were sieved aboard ship through a 1.0-mm mesh screen. Organisms retained on the screen were relaxed for 30 minutes in a magnesium sulfate solution and then fixed in buffered formalin (see City of San Diego 2003). After a minimum of 72 hours, each sample was rinsed with fresh water and transferred to 70% ethanol. All organisms were sorted from the debris into major taxonomic groups by a subcontractor (MEC Analytical Systems, Inc., Carlsbad, California). Biomass was measured as the wet weight in grams per sample for each of the following taxonomic categories: Polychaeta (Annelida), Crustacea (Arthropoda), Mollusca, Ophiuroidea (Echinodermata), non-ophiuroid Echinodermata, and all other phyla combined (e.g., Chordata, Cnidaria, Nemertea, Platyhelminthes, Phoronida, Sipuncula). Values for ophiuroids and all other echinoderms were later combined to give a total echinoderm biomass. After biomassing, all animals were identified to species or the lowest taxon possible and enumerated by City of San Diego marine biologists.

## Data Analyses

The following community structure parameters were calculated for each station: species richness (number of species per 0.1-$m^2$ grab); total number of species per station (i.e., cumulative of two replicate samples); abundance (number of individuals per grab); biomass (grams per grab, wet weight); Shannon diversity index (H' per grab); Pielou's evenness index (J' per grab); Swartz dominance (minimum number of species accounting for 75% of the total abundance in each grab); Infaunal Trophic Index (ITI per grab) (see Word 1980); and Benthic Response Index (BRI per grab) (see Smith et al. 2001).

Ordination (principal coordinates) and classification (hierarchical agglomerative clustering) analyses were performed to examine spatio-temporal patterns in the overall similarity of benthic assemblages in the region. These analyses were performed using Ecological Analysis Package (EAP) software (see Smith 1982, Smith et al. 1988). The macrofaunal abundance data were square-root transformed and standardized by the species mean values greater than zero. Prior to analysis the data set was reduced by excluding any species represented by less than 10 individuals over all samples. The effect of such reductions on the outcome of subsequent analyses is considered negligible (see Smith et al. 1988).

## RESULTS & DISCUSSION

### Community Parameters

***Number of Species***

A total of 646 benthic infaunal taxa was identified in 2002, though 22% of these represented rare or unidentifiable taxa that were recorded only once. The average number of taxa per 0.1 $m^2$ grab ranged from 28 to 122 (Table 5.1). This wide variation in species richness can probably be attributed to different habitat types, and the spatial pattern in these values was consistent with previous surveys (see City of San Diego 2002). Higher numbers of species, for example, are common at stations such as I-28, I-35 and I-29 where the sediments contain more fine particles than most SBOO sites (see Chapter 4). In addition, species richness varied seasonally, averaging about 14% higher in July than in January (see Figure 5.2A). Although species richness varied on both spatial and temporal scales in the SBOO region, there was no apparent influence by proximity to the outfall.

Polychaete worms made up the greatest proportion of species, accounting for 28-57% of the taxa at various sites during 2002. Crustaceans composed 15-32% of the species, molluscs from 7 to 22%, echinoderms from 1 to 15%, and all other taxa combined about 4-15%. These percentages are generally similar to those observed during previous years, including prior to discharge (e.g., see City of San Diego 2000, 2002).

***Infaunal Abundance***

Infaunal abundance ranged from a mean of 85 to 352 animals per grab in 2002 (Table 5.1). The greatest number of animals occurred at stations I-29, I-3, I-13 and I-28, which were the only sites that averaged over 300 individuals per sample. Stations I-28 and I-29 are typically characterized by high abundance, with a variety of different taxa accounting for these high numbers (see City of San Diego 2002). In contrast, high abundances at stations I-3 and I-13 were due to unusually large numbers of single taxa. For example, the tanaid crustacean *Leptochelia dubia* accounted for 401 individuals from a single grab at station I-3, while the spionid polychaete *Spiophanes bombyx* was represented by 461 individuals from one grab at station I-13. With respect to the outfall, no clear spatial patterns in infaunal abundance were evident. However, there was a considerable difference in abundance values between the January and July surveys, reflecting a seasonal pattern similar to that described for species richness (see Figure 5.2B). Overall, abundance values were well within the range of historical variation.

Similar to past years, polychaetes were the most abundant animals in the region, accounting for 30-80% of the different assemblages during 2002. Crustaceans averaged 9-47% of the animals at a station, molluscs from 5 to 24%, echinoderms from >1 to 16%, and all remaining taxa about 1-14% combined.

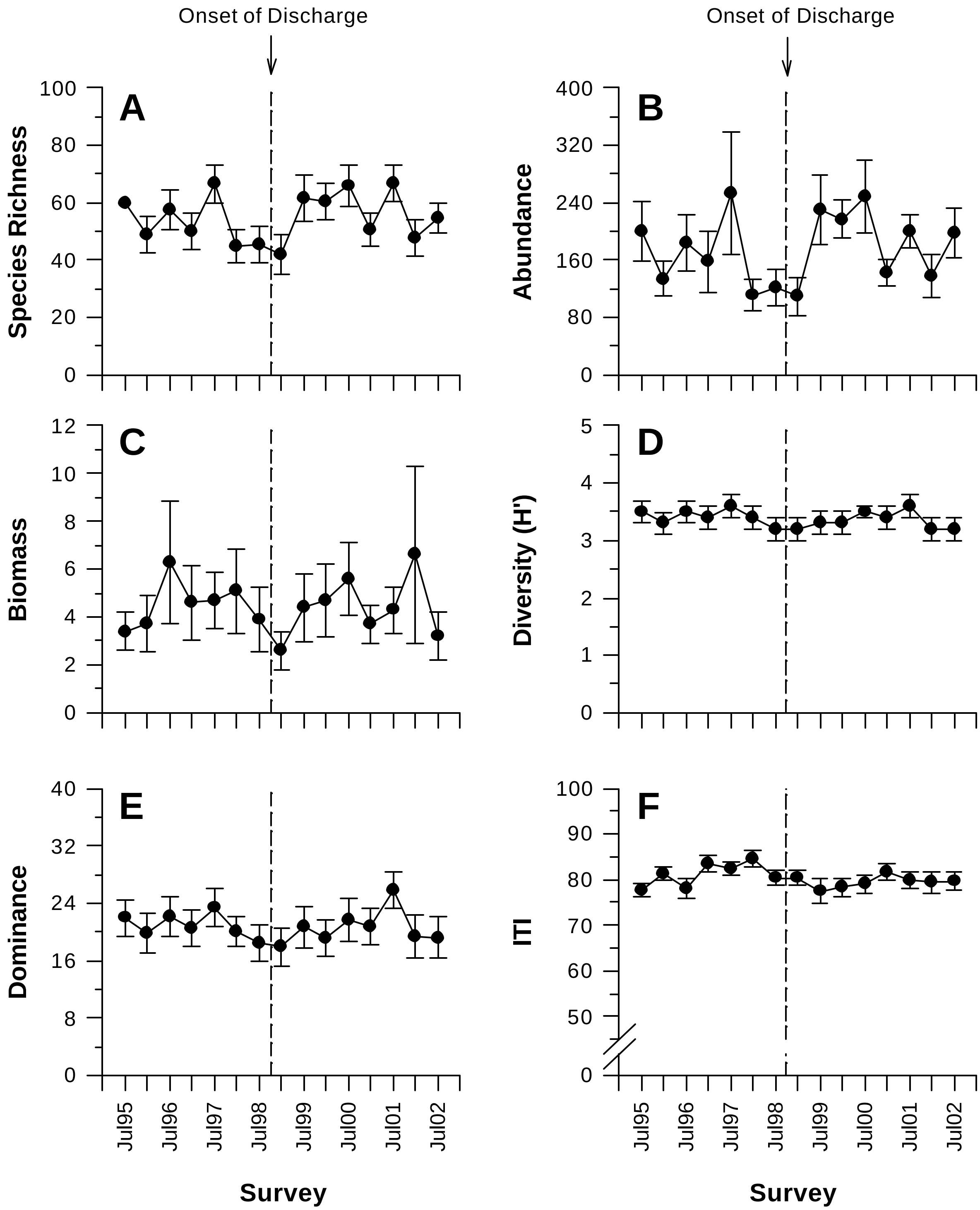
***Biomass***

Total infaunal biomass averaged from 0.9 to 26.7 grams per 0.1 $m^2$ (Table 5.1). High biomass values are often due to the collection of large motile organisms such as sand dollars, sea stars, crabs and snails. For example, during 2002 a single specimen of the gastropod mollusc *Kellettia kellettii* weighed 97.5 grams, accounting for

## Table 5.1

Benthic infaunal community parameters at SBOO stations sampled in 2002. Data are expressed as annual means for: species richness, no. species/0.1 $m^2$ (SR); total no. species per site (Tot spp); abundance/0.1 $m^2$ (Abun); biomass, g/0.1 $m^2$; diversity (H'); evenness (J'); Swartz dominance, no. species composing 75% of a community by abundance (Dom); infaunal trophic index (ITI); benthic response index (BRI).

| | SR | Tot spp | Abun | Biomass | H' | J' | Dom | ITI | BRI |
|---|---|---|---|---|---|---|---|---|---|
| *19 m stations* | | | | | | | | | |
| I-35 | 72 | 98 | 191 | 5.7 | 3.9 | 0.9 | 32 | 77 | 25 |
| I-34 | 28 | 44 | 96 | 5.0 | 2.6 | 0.8 | 9 | 74 | -2 |
| I-31 | 39 | 55 | 107 | 0.9 | 3.0 | 0.8 | 15 | 79 | 10 |
| I-23 | 52 | 80 | 149 | 26.7 | 3.4 | 0.9 | 19 | 82 | 12 |
| I-18 | 41 | 62 | 106 | 1.0 | 3.1 | 0.8 | 16 | 76 | 12 |
| I-10 | 43 | 65 | 146 | 1.1 | 3.0 | 0.8 | 13 | 81 | 11 |
| I-4 | 45 | 79 | 174 | 2.4 | 3.0 | 0.8 | 14 | 65 | 7 |
| *28 m stations* | | | | | | | | | |
| I-33 | 91 | 136 | 222 | 3.8 | 4.1 | 0.9 | 40 | 82 | 22 |
| I-30 | 45 | 66 | 104 | 5.1 | 3.5 | 0.9 | 22 | 80 | 22 |
| I-27 | 38 | 55 | 85 | 1.3 | 3.3 | 0.9 | 18 | 82 | 22 |
| I-22 | 52 | 78 | 138 | 2.0 | 3.5 | 0.9 | 23 | 82 | 19 |
| I-14 | 55 | 78 | 151 | 1.9 | 3.6 | 0.9 | 24 | 82 | 22 |
| I-16 | 52 | 81 | 138 | 1.6 | 3.2 | 0.8 | 21 | 76 | 18 |
| I-15 | 54 | 89 | 185 | 9.1 | 3.1 | 0.8 | 17 | 81 | 16 |
| I-12 | 36 | 58 | 111 | 7.4 | 2.8 | 0.8 | 13 | 74 | 17 |
| I-9 | 66 | 100 | 182 | 2.3 | 3.7 | 0.9 | 26 | 82 | 20 |
| I-6 | 42 | 67 | 171 | 12.1 | 2.9 | 0.8 | 13 | 74 | 9 |
| I-2 | 29 | 43 | 105 | 1.2 | 2.6 | 0.8 | 10 | 73 | 11 |
| I-3 | 42 | 65 | 330 | 11.6 | 2.5 | 0.7 | 8 | 70 | 9 |
| *38 m stations* | | | | | | | | | |
| I-29 | 63 | 109 | 352 | 4.3 | 3.2 | 0.8 | 16 | 87 | 17 |
| I-21 | 36 | 55 | 89 | 4.9 | 3.2 | 0.9 | 16 | 89 | 1 |
| I-13 | 49 | 79 | 327 | 3.5 | 2.4 | 0.6 | 9 | 80 | 11 |
| I-8 | 49 | 72 | 183 | 4.8 | 3.0 | 0.8 | 16 | 80 | 15 |
| *55 m stations* | | | | | | | | | |
| I-28 | 122 | 171 | 311 | 4.9 | 4.4 | 0.9 | 55 | 85 | 11 |
| I-20 | 44 | 65 | 145 | 3.5 | 3.2 | 0.9 | 16 | 88 | 6 |
| I-7 | 48 | 72 | 120 | 3.7 | 3.4 | 0.9 | 20 | 89 | 6 |
| I-1 | 53 | 79 | 112 | 1.4 | 3.6 | 0.9 | 25 | 82 | 11 |
| *All stations* | | | | | | | | | |
| Mean | 51 | 78 | 168 | 4.9 | 3.2 | 0.8 | 19 | 80 | 13 |
| Min | 28 | 43 | 85 | 0.9 | 2.4 | 0.6 | 8 | 65 | -2 |
| Max | 122 | 171 | 352 | 26.7 | 4.4 | 0.9 | 55 | 89 | 25 |




## Figure 5.2

Summary of benthic community structure parameters surrounding the South Bay Ocean Outfall (1995 – 2002). (A) Species Richness = number of species; (B) Abundance = number of animals; (C) Biomass = grams, wet weight; (D) Diversity = Shannon diversity index (H'); (E) Dominance = Swartz dominance index; (F) ITI = infaunal trophic index. Data are expressed as means per $0.1m^2$ grab pooled over all stations for each survey (n = 54). Error bars represent 95% confidence limits.

over 91% of the annual biomass at station I-23 (Table 5.1), and over 27% of the biomass for all stations during the January survey (Figure 5.2C). A second large specimen of *K. kellettii* (20.8 g) had a similar impact on the biomass at station I-12. In addition, large specimens of the molluscs *Simomactra planulata* and *Megasurcula carpenteriana*, or the echinoderms *Dendraster terminalis*, *Astropectin verrilli* and *Lovenia cordiformis* skewed the biomass at several stations (e.g., stations I-3, I-6). Although these megabenthic invertebrates can introduce considerable variability, biomass at the SBOO stations during 2002 was similar to historical values (Figure 5.2C).

Overall, polychaetes accounted for 5-68% of the biomass at a station, crustaceans 1-74%, molluscs 2-93%, echinoderms >1-3%, and all other taxa combined 1-35%. In the absence of large individual molluscs or echinoderms, polychaetes dominated most stations in terms of biomass.

***Species Diversity and Dominance***

Species diversity (H') ranged from 2.4 to 4.4 during 2002, and was generally similar to background conditions (Table 5.1, Figure 5.2D). Spatial patterns were also generally consistent with previous years (see City of San Diego 2002). The two lowest diversity values (stations I-13 and I-3) reflect high numbers of individual species, discussed above in terms of abundance. Most of the SBOO stations were characterized by a fairly even distribution of species (i.e., mean J' = 0.8-0.9), with the lowest values again at stations I-13 and I-3 (J' = 0.6 and 0.7, respectively).

Species dominance was measured as the minimum number of species accounting for 75% of a community by abundance (see Swartz 1978). Consequently, dominance as discussed herein is inversely proportional to numerical dominance, such that low values indicate communities dominated by few species. Values at individual stations varied widely, averaging from 8 to 55 species per station during the year (Table 5.1). Overall, dominance was within the range of historical values for the SBOO region (Figure 5.2E). No clear patterns relative to the outfall were evident in terms of diversity, evenness, or dominance.

***Environmental Disturbance Indices***

The benthic response index (BRI) during 2002 averaged from -2 to 25 at the various SBOO stations (Table 5.1). Index values below 25 (on a scale of 100) suggest undisturbed communities or "reference conditions," and those in the range of 25-33 only represent "a minor deviation from reference condition" which may or may not reflect anthropogenic impact (Smith et al. 2001). Station I-35 had the highest BRI, and was the only station above the upper limit for reference conditions. There were no patterns in BRI relative to distance from the outfall, and index values at sites nearest the discharge did not suggest significant environmental disturbance.

The infaunal trophic index (ITI) averaged from 65 to 89 at the various sites in 2002 (Table 5.1). There were no patterns with respect to the outfall, and all values at sites near the discharge were characteristic of undisturbed sediments (i.e., ITI > 60, Word 1980). In addition, average ITI over all sites has changed little since monitoring began (see Figure 5.2F).

## Table 5.2

Dominant macroinvertebrates at the SBOO benthic stations sampled during 2002. Included are the 10 most abundant species overall and per occurrence, and the 10 most widely distributed species. Abundance values are summarized over all stations and are expressed as means per 0.1 $m^2$ over all samples (MS) and per occurrence (MO); PO = percent occurrence.

| Species | Higher taxa | MS | MO | PO |
|---|---|---|---|---|
| Top 10 Species Overall | | | | |
| 1. *Spiophanes bombyx* | Polychaeta: Spionidae | 22.8 | 23.3 | 98% |
| 2. *Spiophanes duplex* | Polychaeta: Spionidae | 5.7 | 7.9 | 72% |
| 3. *Leptochelia dubia* | Crustacea: Tanaidacea | 5.4 | 10.4 | 52% |
| 4. *Tellina modesta* | Mollusca: Bivalvia | 3.8 | 6.2 | 61% |
| 5. *Euchone arenae* | Polychaeta: Sabellidae | 3.3 | 9.5 | 35% |
| 6. *Ampelisca cristata cristata* | Crustacea: Amphipoda | 2.9 | 3.6 | 80% |
| 7. *Monticellina siblina* | Polychaeta: Cirratulidae | 2.7 | 4.5 | 61% |
| 8. *Hemilamprops californicus* | Crustacea: Cumacea | 2.3 | 3.8 | 61% |
| 9. Maldanidae † | Polychaeta: Maldanidae | 2.3 | 2.7 | 83% |
| 10. *Lumbrineris latreilli* | Polychaeta: Lumbrineridae | 2.2 | 14.9 | 15% |
| Top 10 Species per Occurrence | | | | |
| 1. *Spiophanes bombyx* | Polychaeta: Spionidae | 22.8 | 23.3 | 98% |
| 2. *Lumbrineris latreilli* | Polychaeta: Lumbrineridae | 2.2 | 14.9 | 15% |
| 3. *Leptochelia dubia* | Crustacea: Tanaidacea | 5.4 | 10.4 | 52% |
| 4. *Euchone arenae* | Polychaeta: Sabellidae | 3.3 | 9.5 | 35% |
| 5. *Lanassa venusta venusta* | Polychaeta: Terebellidae | 1.7 | 9.3 | 19% |
| 6. *Micropodarke dubia* | Polychaeta: Hesionidae | 0.8 | 9.0 | 9% |
| 7. *Nephasoma diaphanes* | Sipuncula: Golfingiidae | 0.2 | 8.5 | 2% |
| 8. *Spiophanes duplex* | Polychaeta: Spionidae | 5.7 | 7.9 | 72% |
| 9. *Mooreonuphis* sp SD 1 | Polychaeta: Onuphidae | 1.3 | 7.3 | 19% |
| 10. *Hesionura coineaui difficilis* | Polychaeta: Phyllodocidae | 0.5 | 6.8 | 7% |
| Top 10 Widespread Species | | | | |
| 1. *Spiophanes bombyx* | Polychaeta: Spionidae | 22.8 | 23.3 | 98% |
| 2. Maldanidae † | Polychaeta: Maldanidae | 2.3 | 2.7 | 83% |
| 3. *Sigalion spinosus* | Polychaeta: Sigalionidae | 2.0 | 2.5 | 82% |
| 4. *Ampelisca cristata cristata* | Crustacea: Amphipoda | 2.9 | 3.6 | 80% |
| 5. *Spiophanes duplex* | Polychaeta: Spionidae | 5.7 | 7.9 | 72% |
| 6. Eulcymeninae sp A | Polychaeta: Maldanidae | 1.2 | 1.8 | 69% |
| 7. *Glottidia albida* | Brachiopoda: Inarticulata | 1.0 | 1.5 | 67% |
| 8. *Foxiphalus obtusidens* | Crustacea: Amphipoda | 1.7 | 2.7 | 65% |
| 9. *Onuphis* sp SD 1 | Polychaeta: Onuphidae | 1.4 | 2.2 | 63% |
| 10. Amphiuridae † | Echinodermata: Ophiuroidea | 1.0 | 1.5 | 63% |

† = unidentified juveniles and/or damaged specimens

## Dominant Species

Most assemblages in the SBOO region were dominated by polychaete worms. For example, the list of dominant infauna in Table 5.2 includes 13 polychaetes, four crustaceans, one mollusc, one echinoderm, one sipunculid and one brachiopod.

The spionid polychaete *Spiophanes bombyx* was the most abundant and the most ubiquitous species, averaging about 23 worms per grab and occurring in 98% of the samples. Only three other species were present in at least 80% of the samples. These included two polychaetes (*Sigalion spinosus* and unidentified Maldanidae) and one amphipod (*Ampelisca cristata cristata*). In addition to *S. bombyx*, other abundant species were the spionid polychaete *Spiophanes duplex* and the tanaid crustacean *Leptochelia dubia*.

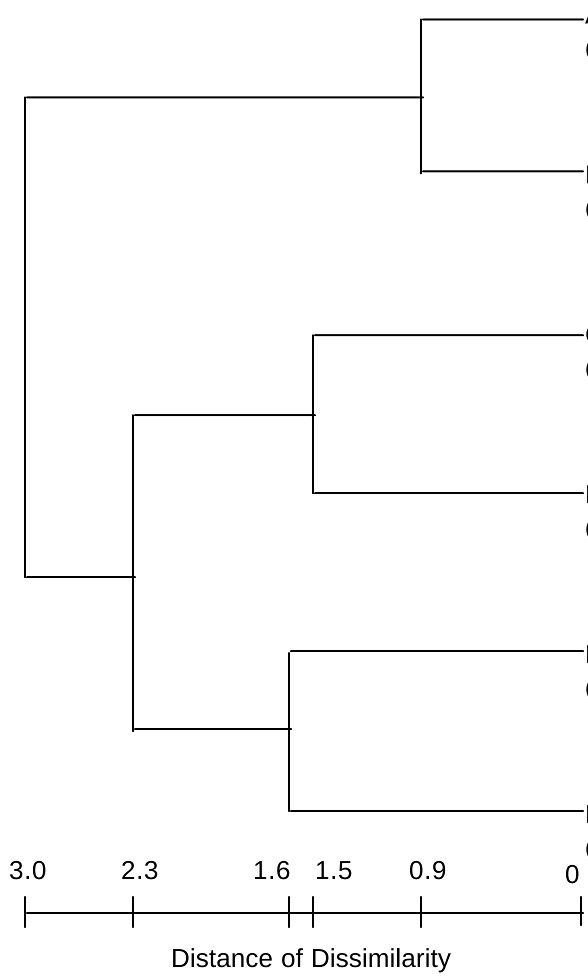
## Pattern Analysis

Ordination and classification analyses discriminated between six habitat-related benthic assemblages (cluster groups A-F) during 2002 (see Figures 5.3 and 5.4). These assemblages differed in terms of their species composition, including the specific taxa present and their relative abundances. The dominant species composing each group are listed in Table 5.3. Sediment grain size (i.e., fine vs. coarse sediments) and depth appeared to be the major factors affecting infaunal distribution in the region (see Figures 5.3, 5.4 and Figure 4.2 in chapter 4). There were no significant patterns regarding proximity to the discharge.

Cluster group A included sites that were primarily located along the 28-m depth contour (see Figures 5.3 and 5.4). Sediments here contained the second highest amount of fine particles, and supported a relatively diverse assemblage that averaged 62 species per 0.1 $m^2$. The most abundant species were the bivalve mollusc *Tellina modesta*, followed by the polychaetes, *Monticellina siblina* and *Spiophanes bombyx*.

Cluster group B included shallow water sites located along the 19-m depth contour. These sites are subject to higher wave activity than deeper areas, and therefore the sediments contain less fine particles. Overall, this assemblage was less diverse than those from deeper waters, with an average species richness value of 44. The dominant species in this group included two spionid polychaetes, *Spiophanes duplex* and *Spiophanes bombyx*, and the amphipod *Ampelisca cristata cristata*.

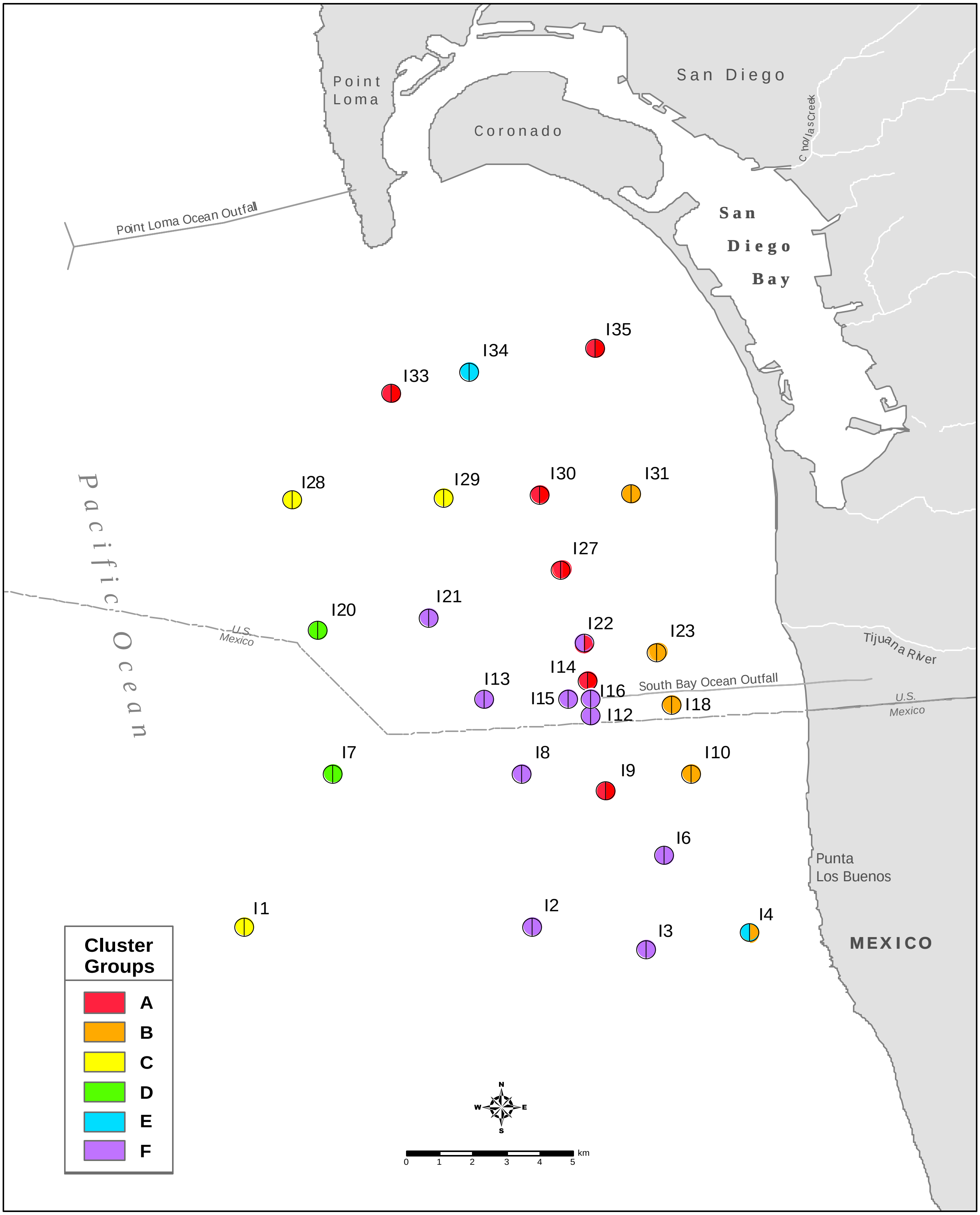
Cluster group C comprised three stations located along the 38 and 55-m depth contours. Sediments at these sites contained more fine particles than elsewhere in the region. The group C assemblage was characterized by high species richness and abundance, averaging 79 taxa and 258 individuals per grab. Polychaetes dominated this group, with the most abundant species including *Lumbrineris latreilli*, *Euchone arenae* and *Lanassa venusta venusta*. The following polychaetes were also characteristic of this assemblage, but relatively uncommon in other groups: the hesionid *Micropodarke dubia*, the sigalionid *Sthenelanella uniformis* and the syllid *Syllis (Typosyllis)* sp SD 1 (Table 5.3).




| CG | Stations | Depth(m) | Fines (%) | SR | ABUN | Top Three Taxa |
|---|---|---|---|---|---|---|
| A (n=13) | I-35, I-33, I-30, I-27, I-22b, I-14, I-9 | 27 (19-30) | 17.5 (4.5-39.4) | 62 (25-123) | 160 (62-363) | *Tellina modesta* *Monticellina siblina* *Spiophanes bombyx* |
| B (n=9) | I-31, I-23, I-18, I-10, I-4b | 19 (18-21) | 7.9 (0.9-10.8) | 44 (23-62) | 136 (62-220) | *Spiophanes duplex* *Spiophanes bombyx* *Ampelisca cristata cristata* |
| C (n=6) | I-28, I-29, I-1 | 51 (38-60) | 27.4 (9.7-39.2) | 79 (38-138) | 258 (87-830) | *Lumbrineris latreilli* *Euchone arenae* *Lanassa venusta venusta* |
| D (n=4) | I-20, I-7 | 54 (52-55) | 0.2 (0-0.5) | 46 (33-59) | 132 (80-232) | *Mooreonuphis sp SD 1* *Mooreonuphis sp* *Apionsoma misakianum* |
| E (n=3) | I-34, I-4a | 19 (18-19) | 3.4 (0-9.8) | 31 (18-51) | 112 (43-177) | *Dendraster terminalis* *Photis macinerneyi* *Spiophanes bombyx* |
| F (n=19) | I-21, I-22a, I-13, I-15, I-16, I-12, I-8, I-6, I-2, I-2, I-3 | 32 (26-41) | 2.8 (0-15.0) | 43 (20-77) | 176 (56-747) | *Spiophanes bombyx* *Leptochelia dubia* *Euchone arenae* |

## Figure 5.3

Cluster results of the infaunal abundance data for the SBOO benthic stations sampled during January and July, 2002. Station designations: a=January survey, b=July survey, no letter designation=both surveys. Data are expressed as means per 0.1 $m^2$ grab over all stations in each group. CG=cluster group; Fines=percentage of silt + clay fraction of sediments; SR=number of species; ABUN=number of individuals; Ranges in parentheses are for individual grab samples.




## Figure 5.4

SBOO benthic infauna stations sampled during January and July, 2002. Colors represent affiliation with infaunal cluster groups A - F. Left and right halves of each circle represent cluster group affiliation with the January and July surveys, respectively.

## Table 5.3

Summary of the most abundant taxa composing cluster groups A-F from the 2002 infaunal survey of SBOO benthic stations. Data are expressed as mean abundance per sample (no./0.1m$^2$) and represent the ten most abundant taxa in each group. Values for the three most abundant species (bolded) in each cluster group are underlined. n=number of station/survey entities per cluster group.

| | | Cluster Group | | | | | |
|---|---|---|---|---|---|---|---|
| **Species/Taxa** | **Higher Taxa Code*** | **A** (n=13) | **B** (n=9) | **C** (n=6) | **D** (n=4) | **E** (n=3) | **F** (n=19) |
| *Nuculana taphria* | M | 4.0 | 0.6 | 0.3 | . | 0.8 | 0.1 |
| ***Monticellina siblina*** | P | <u>7.2</u> | 0.6 | 1.9 | . | 0.2 | 1.9 |
| ***Spiophanes duplex*** | P | 4.3 | <u>23.0</u> | 3.9 | 0.8 | 4.2 | 0.2 |
| *Scalibregma inflatum* | P | 0.1 | 2.7 | 1.2 | . | . | . |
| *Ampelisca cristata microdentata* | C | 5.0 | 0.5 | 1.0 | . | . | 0.1 |
| *Rhepoxynius stenodes* | C | 2.0 | 4.7 | . | . | 0.3 | 0.2 |
| ***Tellina modesta*** | M | <u>10.1</u> | 4.9 | 0.1 | . | 0.8 | 1.4 |
| *Rhepoxynius menziesi* | C | 4.0 | 2.2 | 0.2 | . | 2.0 | 0.5 |
| *Ampelisca brachycladus* | C | 1.5 | 3.3 | . | . | 2.3 | 0.5 |
| *Sthenelanella uniformis* | P | 0.5 | 0.1 | 6.0 | . | . | <0.1 |
| Maldanidae, unidentified | P | 3.4 | 3.1 | 1.3 | 0.4 | 3.3 | 1.6 |
| *Sigalion spinosus* | P | 2.7 | 3.8 | 1.6 | 1.4 | 1.5 | 1.0 |
| *Hemilamprops californicus* | C | 4.4 | 1.2 | 4.6 | 0.1 | 0.3 | 1.4 |
| *Euphilomedes carcharodonta* | C | 1.5 | 0.2 | 1.8 | 0.3 | . | 2.5 |
| ***Ampelisca cristata cristata*** | C | 3.0 | <u>5.7</u> | 1.2 | 2.9 | 0.7 | 2.3 |
| ***Spiophanes bombyx*** | P | <u>5.4</u> | <u>16.2</u> | 2.2 | 8.0 | <u>7.5</u> | <u>50.0</u> |
| *Magelona sacculata* | P | 0.8 | 2.4 | . | . | 5.2 | 0.8 |
| *Anchicolurus occidentalis* | C | 0.1 | 0.7 | . | . | 3.7 | 0.4 |
| ***Photis macinerneyi*** | C | . | 0.3 | . | . | <u>10.7</u> | 0.2 |
| *Metharpinia jonesi* | C | . | . | . | . | 3.3 | . |
| *Axiothella rubrocincta* | P | 0.2 | . | . | 0.1 | . | 3.2 |
| Nematoda, unidentified | N | 0.2 | 0.5 | 3.9 | 0.5 | 0.8 | 1.6 |
| ***Leptochelia dubia*** | C | 0.6 | 0.4 | 2.3 | 1.0 | . | <u>13.8</u> |
| *Protodorvillea gracilis* | P | . | 0.3 | 0.8 | 0.9 | 6.8 | 2.8 |
| *Rhepoxynius heterocuspidatus* | C | . | 0.1 | . | 0.4 | 0.2 | 4.3 |
| *Caecum crebricinctum* | M | . | 0.8 | 0.3 | 2.6 | 2.5 | 3.6 |
| *Spio maculata* | P | . | . | 0.2 | 6.0 | 1.5 | 1.5 |
| ***Dendraster terminalis*** | E | . | . | . | . | <u>12.0</u> | 3.5 |
| *Ophelia pulchella* | P | . | . | . | . | 1.7 | 2.7 |
| ***Lumbrineris latreilli*** | P | . | . | <u>18.8</u> | 0.5 | 0.3 | 0.2 |
| *Micropodarke dubia* | P | <0.1 | . | 7.2 | . | . | 0.1 |
| *Syllis (Typosyllis)* sp SD 1 | P | <0.1 | . | 5.2 | 0.3 | . | 0.8 |
| *Polycirrus* sp A | P | 0.2 | 0.1 | 5.3 | 4.6 | . | 0.3 |
| ***Lanassa venusta venusta*** | P | . | . | <u>11.8</u> | 4.6 | . | 0.2 |
| ***Apionsoma misakianum*** | S | <0.1 | . | 8.8 | <u>8.5</u> | 0.2 | 0.3 |
| *Jasmineira* sp B | P | . | . | 1.4 | 3.8 | . | . |
| ***Euchone arenae*** | P | <0.1 | . | <u>14.2</u> | 1.8 | 0.2 | <u>4.6</u> |
| *Ophiuroconis bispinosa* | E | <0.1 | . | 2.1 | 4.9 | . | 0.9 |
| ***Mooreonuphis* sp** | P | 0.2 | . | 0.1 | <u>10.0</u> | . | 0.5 |
| ***Mooreonuphis* sp SD 1** | P | . | . | 0.6 | <u>14.8</u> | . | 0.5 |
| *Lirobarleeia kelseyi* | M | . | . | . | 4.3 | . | <0.1 |

* P = Polychaeta (Annelida), C = Crustacea (Arthropoda), M = Mollusca, E = Echinodermata, N = Nematoda S = Sipuncula.

Cluster group D represented two stations characterized by coarse relict red sand that were located along the 55-m depth contour. In contrast to the other deepwater assemblage described above (group C), this group had fewer taxa and less individual organisms per grab. Polychaetes in the onuphid genera *Mooreonuphis* dominated this group, followed by the sipunculid *Apionsoma misakianum* and the spionid *Spiophanes bombyx*.

Cluster group E included samples from two other shallow water sites (I-34 and I-4) located on the 19-m depth contour. Sediments at these sites were characterized by a relatively low percentage of fine particles. The group E assemblage was the least diverse of any in the SBOO region, averaging only 31 taxa per grab. The echinoderm *Dendraster terminalis* was the most abundant species in this infaunal assemblage, followed by the amphipod crustacean *Photis macinerneyi* and the spionid *Spiophanes bombyx*.

Cluster group F comprised sites that were located along the 28 and 38-m depth contours. These sites averaged a low percentage of fines, with some stations containing relict red sands. The group F assemblage averaged 176 individuals and 43 taxa per grab. *Spiophanes bombyx* was numerically dominant in this group, followed by the tanaid *Leptochelia dubia* and the polychaete *Euchone arenae*. The amphipod *Rhepoxynius heterocuspidatus*, the gastropod *Caecum crebricinctum* and the echinoderm *Dendraster terminalis* were also characteristic of this assemblage (Table 5.3).

## SUMMARY & CONCLUSIONS

Benthic infaunal assemblages surrounding the South Bay Ocean Outfall were similar in 2002 to those that occurred during previous years (City of San Diego 2000, 2002). In addition, these assemblages were generally typical of those occurring in other sandy, shallow water habitats throughout the Southern California Bight (SCB) (e.g., Thompson et al. 1987, 1993b, City of San Diego 1999, Bergen et al. 2001). For example, several of the assemblages described herein (e.g, groups A, B, E, F) contained high numbers of the spionid polychaete *Spiophanes bombyx*, a species characteristic of shallow-water environments in the SCB (see Bergen et al. 2001). These four groups represented sub-assemblages of the shallow SCB benthos that differed in the relative abundances of dominant and co-dominant species. Such differences probably reflect variation in microhabitat structure, such as the presence of a fine sediment component (i.e., group A), the influence of increased water movement in shallower areas (i.e., groups B and E), or coarser sediments, such as relict red sands (i.e., group F). In contrast, the group C assemblage occurs in slightly deeper water habitats that probably represent a transition between the shallow sandy sediments common in the area and the finer mid-depth sediments characteristic of much of the SCB mainland shelf (see Barnard and Ziesenhenne 1961, Jones 1969, Fauchald and Jones 1979, Thompson et al. 1987, 1993a, b, EcoAnalysis et al. 1993, Zmarzly et al. 1994, Diener and Fuller 1995, Bergen et al. 2001). Although dominated by various polychaete species, overall this assemblage was more diverse than others in the SBOO region. Finally, group D represented a second relict red sand assemblage that occurred in deeper waters than group F. This assemblage was dominated by onuphid worms and the sipunculid *Apionsoma misakianum*.

Infaunal distribution and abundance in the region varied along gradients of sediment type and depth, with no clear spatial patterns relative to the outfall. Temporal patterns also suggest that the benthic community has not been significantly impacted by the SBOO. For example, the overall range of values for the different community parameters in 2002 was similar to that seen in previous years (see City of San Diego 2000, 2002). In addition, environmental disturbance indices such as the ITI and the BRI were generally characteristic of assemblages from undisturbed sediments.

Anthropogenic impacts have spatial and temporal dimensions that can vary depending on a range of biological and physical factors. Such impacts can be difficult to detect, and specific effects of the SBOO discharge could not be identified during 2002. Furthermore, benthic invertebrate populations exhibit substantial spatial and temporal variability that may mask the effects of any disturbance event (Morrisey et al. 1992a, b, Otway 1995). Although some changes have likely occurred near the SBOO, benthic assemblages in the area remain similar to those observed prior to discharge and to natural indigenous communities characteristic of similar habitats on the southern California continental shelf.

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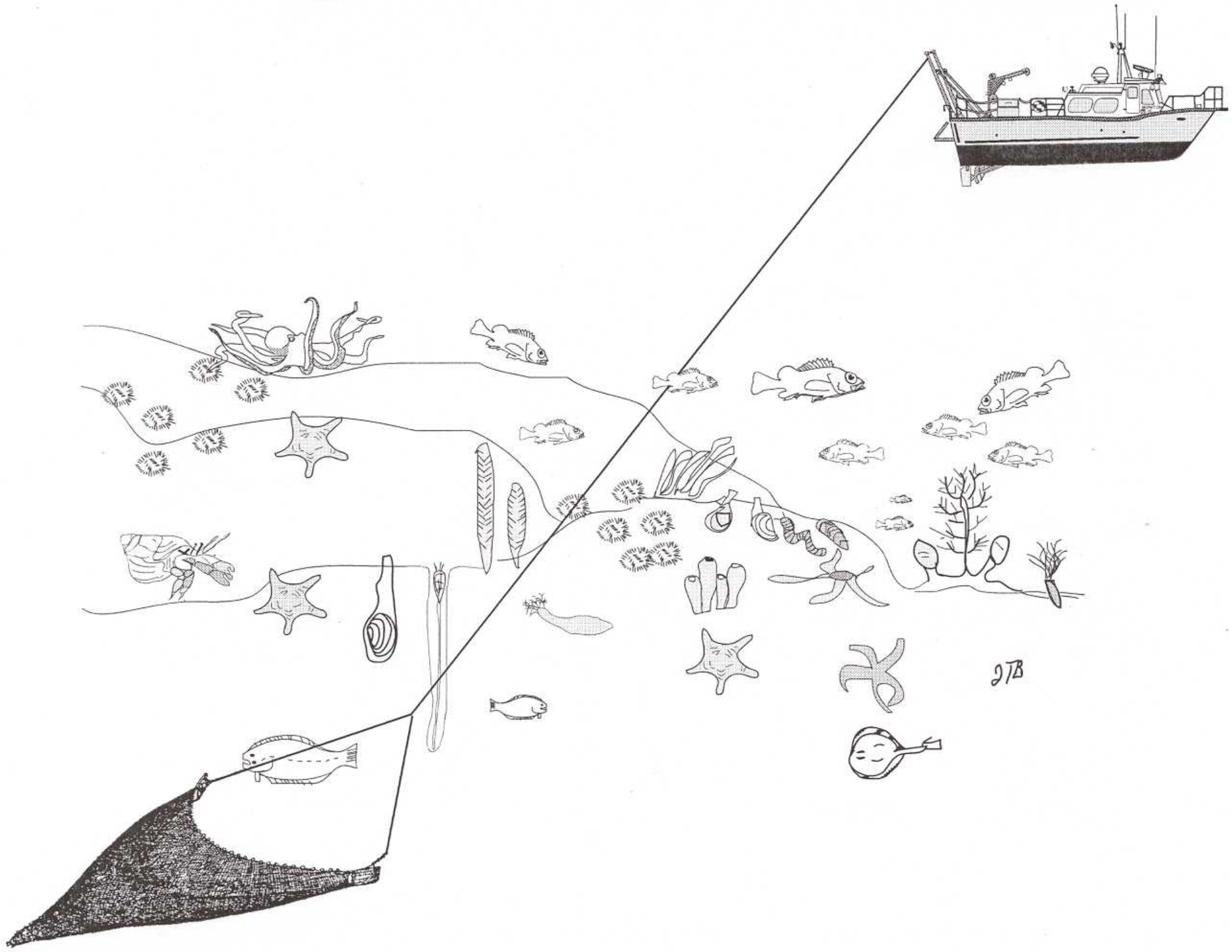
# Demersal Fishes and Megabenthic Invertebrates



# Chapter 6

# Demersal Fishes and Megabenthic Invertebrates

## INTRODUCTION

Demersal fish and megabenthic invertebrate communities have become an important focus of monitoring programs throughout the world. Fish and invertebrate assemblages of the Southern California Bight (SCB) mainland shelf have been sampled extensively for at least 30 years, primarily by programs associated with municipal wastewater and power plant discharges (Cross and Allen 1993). More than 100 species of fish inhabit the SCB, while the megabenthic invertebrate fauna consists of more than 200 species (Allen 1982, Love et al. 1986, Allen et al. 1998). For the region surrounding the South Bay Ocean Outfall, the most common trawl-caught fishes include speckled sanddab, longfin sanddab, hornyhead turbot, California halibut, California lizardfish and occasionally white croaker. The common trawl-caught invertebrates include relatively large species such as sea urchins and sand dollars.

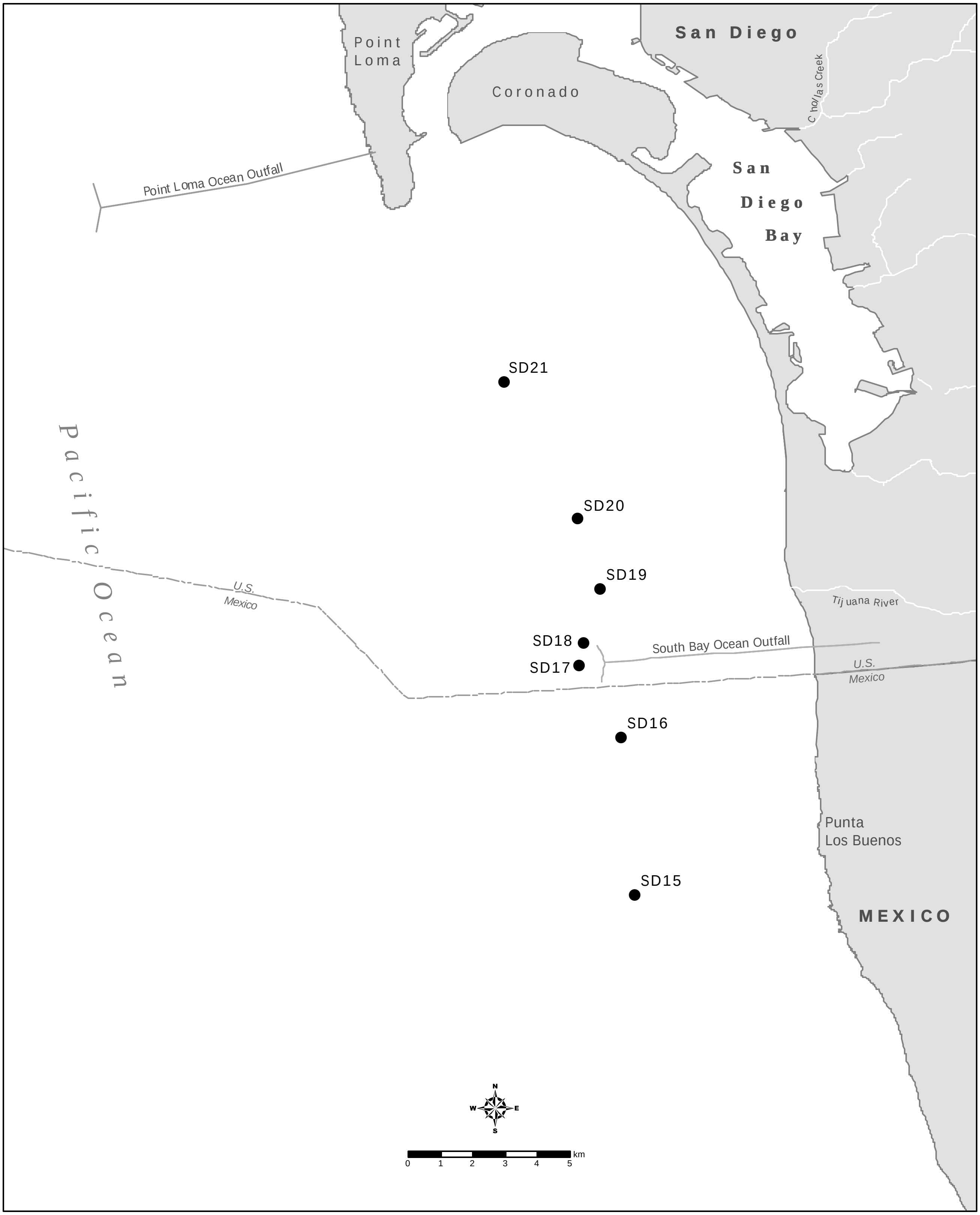
The City of San Diego has been conducting trawl surveys in the area surrounding the South Bay Ocean Outfall (SBOO) since 1995. These surveys were designed to monitor the effects of wastewater discharge on the local marine biota by characterizing their community structure and stability. This chapter presents analyses and interpretations of demersal fish and megabenthic invertebrate data collected during 2002.

## MATERIALS & METHODS

### Field Sampling

Trawl surveys were conducted in January, April, July and October 2002 at seven fixed sites around the SBOO (Figure 6.1). These stations, SD15 - SD21, are located along the 27-m isobath, and encompass an area south of Point Loma, California, USA to Punta Bandera, Baja California, Mexico. During each survey a single trawl was performed at each station using a 7.6-m Marinovich otter trawl fitted with a 1.3-cm cod-end mesh net. The net was towed for 10 minutes bottom time at a speed of about 2.5 knots along a predetermined heading. Detailed methods for locating the stations and conducting trawls are described in the City of San Diego Quality Assurance Manual (City of San Diego 2003).

Trawl catches were brought on board for sorting and inspection. All organisms were identified to species or to the lowest taxon possible. If an animal could not be identified in the field, it was returned to the laboratory for further identification. The total number of individuals and the total biomass (wet weight, kg) were recorded for each species of fish. Additionally, each fish was inspected for the presence of external parasites or physical anomalies (e.g., tumors, fin erosion, discoloration) and measured to the nearest centimeter according to standard protocols (see City of San Diego 2003). The total number of individuals was also recorded for each invertebrate




## Figure 6.1
Otter trawl station locations, South Bay Ocean Outfall Monitoring Program (SD15-SD21).

species. Due to the small size of most organisms, invertebrate biomass was primarily measured as a composite wet weight (kg) of all species combined; however, large or exceptionally abundant species were weighed separately. When the white sea urchin *Lytechinus pictus* was collected in large numbers, its abundance was estimated by multiplying the total number of individuals per 1.0 kg subsample by the total urchin biomass.

### Data Analyses

Populations of each fish and invertebrate species were summarized in terms of frequency of occurrence (number of occurrences/total number of trawls x 100), percent abundance (number of individuals/total of all individuals caught x 100), mean abundance per haul (number of individuals/total number of trawls), and mean abundance per occurrence (number of individuals/number of occurrences). In addition, the following parameters were calculated for both the fish and invertebrate assemblages at each station: (1) species richness (number of species); (2) total abundance; (3) Shannon diversity index (H'); (4) total biomass.

Ordination (principal coordinates) and classification (hierarchical agglomerative clustering) analyses were performed to examine spatio-temporal patterns in the dissimilarity of demersal fish and megabenthic invertebrate assemblages in the region. Data were limited to October surveys only in order to exclude seasonal effects. The total abundance per trawl for each species was square-root transformed and standardized by species mean of values greater than zero prior to analyes. All analyses were performed using Ecological Analysis Package (EAP) software (see Smith 1982, Smith et al. 1988).

## RESULTS & DISCUSSION

### Fish Community

Thirty-four species of fish were collected in the area surrounding the SBOO during 2002 (Table 6.1). The total catch for the year was 2,907 individuals, representing an average of about 104 fish per trawl. The speckled sanddab comprised 76% of the total catch and was the most abundant fish collected. This common species was the only species present in all of the hauls. Other fishes present in at least 50% of the trawls were hornyhead turbot, spotted turbot, California halibut and California lizardfish. The California halibut had an average length of 33 cm, while the rest of these common species tended to be relatively small (< 17 cm in length on average, Appendix B.1). Other species greater than 25 cm in length were collected infrequently and included Pacific angel shark, thornback, California skate and barred sand bass.

Community parameters varied among the stations and between surveys during the year (Table 6.2). For example, abundance was highly variable, ranging from 20 to 191 fish per haul. This large variation was partly due to large catches of speckled sanddab at most stations in April and July. Biomass was also highly variable and generally attributable larger hauls or the presence of a few large individuals. While species richness and diversity values

## Table 6.1

Demersal fish species collected in 28 trawls in the SBOO region during 2002. Data for each species are expressed as: (1) percent abundance (PA); (2) frequency of occurrence (FO); (3) mean abundance per haul (MAH); and (4) mean abundance per occurrence (MAO).

| Species | PA | FO | MAH | MAO |
|---|---|---|---|---|
| Speckled sanddab | 76 | 100 | 79 | 79 |
| Hornyhead turbot | 3 | 86 | 4 | 4 |
| Spotted turbot | 1 | 61 | 1 | 2 |
| California halibut | 1 | 57 | 1 | 2 |
| California lizardfish | 1 | 57 | 2 | 3 |
| California tonguefish | 1 | 46 | 2 | 3 |
| Longfin sanddab | 4 | 43 | 5 | 11 |
| English sole | 1 | 39 | 1 | 3 |
| Fantail sole | <1 | 39 | <1 | 1 |
| California scorpionfish | 1 | 36 | 1 | 3 |
| Yellowchin sculpin | 2 | 36 | 2 | 5 |
| Roughback sculpin | 1 | 29 | 1 | 5 |
| White croaker | 3 | 21 | 3 | 14 |
| Specklefin midshipman | <1 | 21 | <1 | 2 |
| Longspine combfish | <1 | 14 | <1 | 2 |
| Plainfin midshipman | <1 | 14 | <1 | 2 |
| Shiner perch | <1 | 14 | <1 | 3 |
| Bigmouth sole | <1 | 11 | <1 | 1 |
| California skate | <1 | 11 | <1 | 1 |
| Pacific pompano | <1 | 11 | <1 | 4 |
| Queenfish | <1 | 11 | <1 | 2 |
| Curlfin sole | <1 | 7 | <1 | 1 |
| Diamond turbot | <1 | 7 | <1 | 1 |
| Unidentified flatfish | <1 | 7 | <1 | 1 |
| Barcheek pipefish | <1 | 4 | <1 | 2 |
| Barred sand bass | <1 | 4 | <1 | 1 |
| Bluespotted poacher | <1 | 4 | <1 | 1 |
| Kelp pipefish | <1 | 4 | <1 | 1 |
| Northern anchovy | <1 | 4 | <1 | 2 |
| Pacific angel shark | <1 | 4 | <1 | 1 |
| Pacific sanddab | <1 | 4 | <1 | 6 |
| Pacific sardine | <1 | 4 | <1 | 1 |
| Pygmy poacher | <1 | 4 | <1 | 1 |
| Thornback | <1 | 4 | <1 | 1 |
| Vermilion rockfish | <1 | 4 | <1 | 1 |

differed among stations and surveys, both were relatively low. The number of species per haul was below 15 at all stations. Diversity values were below 2.1.

Fish community structure has varied in this region since 1996, but none of the observed changes appear to be associated with the initiation of discharge from the South Bay outfall (Figure 6.2). Although species richness has remained fairly consistent, abundances have fluctuated substantially over the years. Annual abundance values, which have averaged between 28 and 178 individuals per station, generally reflect differences in the populations of the dominant species, especially speckled sanddabs. This inter-annual variability also reflects large hauls of schooling species that occur infrequently. For example, large hauls of white croaker were responsible for the

## Table 6.2

Summary of demersal fish community parameters for SBOO stations sampled during 2002. Data are expressed as means and standard deviations for number of species, abundance, diversity (H') and biomass (kg, wet weight); n = 4.

| Parameter | Station | Jan | Apr | Jul | Oct | Mean | SD |
|---|---|---|---|---|---|---|---|
| No. of Species | SD15 | 3 | 11 | 5 | 5 | 6 | 3 |
| | SD16 | 6 | 11 | 5 | 7 | 7 | 3 |
| | SD17 | 11 | 15 | 8 | 7 | 10 | 4 |
| | SD18 | 10 | 12 | 11 | 5 | 10 | 3 |
| | SD19 | 7 | 13 | 3 | 5 | 7 | 4 |
| | SD20 | 8 | 10 | 4 | 5 | 7 | 3 |
| | SD21 | 9 | 12 | 8 | 10 | 10 | 2 |
| | Survey Mean | 8 | 12 | 6 | 6 | | |
| | Survey SD | 3 | 2 | 3 | 2 | | |
| No. of Individuals | SD15 | 70 | 212 | 174 | 20 | 119 | 89 |
| | SD16 | 25 | 149 | 106 | 131 | 103 | 55 |
| | SD17 | 32 | 191 | 117 | 44 | 96 | 74 |
| | SD18 | 46 | 148 | 96 | 73 | 91 | 43 |
| | SD19 | 43 | 181 | 114 | 78 | 104 | 59 |
| | SD20 | 25 | 139 | 77 | 157 | 100 | 60 |
| | SD21 | 43 | 126 | 177 | 113 | 115 | 55 |
| | Survey Mean | 41 | 164 | 123 | 88 | | |
| | Survey SD | 16 | 31 | 38 | 49 | | |
| Diversity (H') | SD15 | 0.3 | 0.5 | 0.1 | 0.9 | 0.5 | 0.3 |
| | SD16 | 1.9 | 0.9 | 0.4 | 0.5 | 0.9 | 0.7 |
| | SD17 | 2.1 | 1.6 | 0.8 | 1.0 | 1.3 | 0.6 |
| | SD18 | 1.8 | 1.4 | 1.2 | 0.6 | 1.2 | 0.5 |
| | SD19 | 1.4 | 1.0 | 0.3 | 0.4 | 0.8 | 0.5 |
| | SD20 | 1.8 | 1.1 | 0.3 | 0.2 | 0.8 | 0.8 |
| | SD21 | 1.4 | 1.3 | 1.2 | 1.0 | 1.2 | 0.2 |
| | Survery Mean | 1.5 | 1.1 | 0.6 | 0.6 | | |
| | Survey SD | 0.6 | 0.4 | 0.4 | 0.3 | | |
| Biomass | SD15 | 0.6 | 4.3 | 3.4 | 1.7 | 2.5 | 1.7 |
| | SD16 | 2.6 | 7.4 | 2.1 | 5.0 | 4.3 | 2.4 |
| | SD17 | 6.4 | 9.2 | 4.1 | 2.6 | 5.6 | 2.9 |
| | SD18 | 3.2 | 6.2 | 4.4 | 2.7 | 4.1 | 1.6 |
| | SD19 | 3.2 | 8.2 | 2.1 | 1.9 | 3.9 | 3.0 |
| | SD20 | 0.8 | 3.8 | 2.1 | 2.1 | 2.2 | 1.2 |
| | SD21 | 5.5 | 6.3 | 6.7 | 4.0 | 5.6 | 1.2 |
| | Survey Mean | 3.2 | 6.5 | 3.6 | 2.9 | | |
| | Survey SD | 2.2 | 2.0 | 1.7 | 1.2 | | |

high abundance at SD21 in 1996, while a large haul of northern anchovy caused the high abundance at SD16 in 2001.

Ordination and classification of sites discriminated between four major cluster groups that mostly reflect different numbers of the more common species (Figure 6.3, Table 6.3). Changes in the assemblages between 1995 and 2002 generally coincided with different oceanographic conditions present during the fall of each year. For example, most of the stations sampled in October of 1997 and 1998 fall into station group SG1, coinciding with the large scale El Niño that occurred during this time (NOAA-CIRES 2003). Following this El Niño event, the assemblages shifted with the La Niña regime that started in 1999 (i.e., SG2). Shifts in these assemblages were primarily due to fluctuating populations of speckled sanddab, California lizardfish, longfin sanddab, California tonguefish, hornyhead turbot, California halibut and white croaker (Table 6.3). In general, station SD15 appears to have a different community than the other six stations, separating clearly from the other stations in five out of eight years. The distinct assemblages found at this station are likely due to the sandy sediments and unique benthic

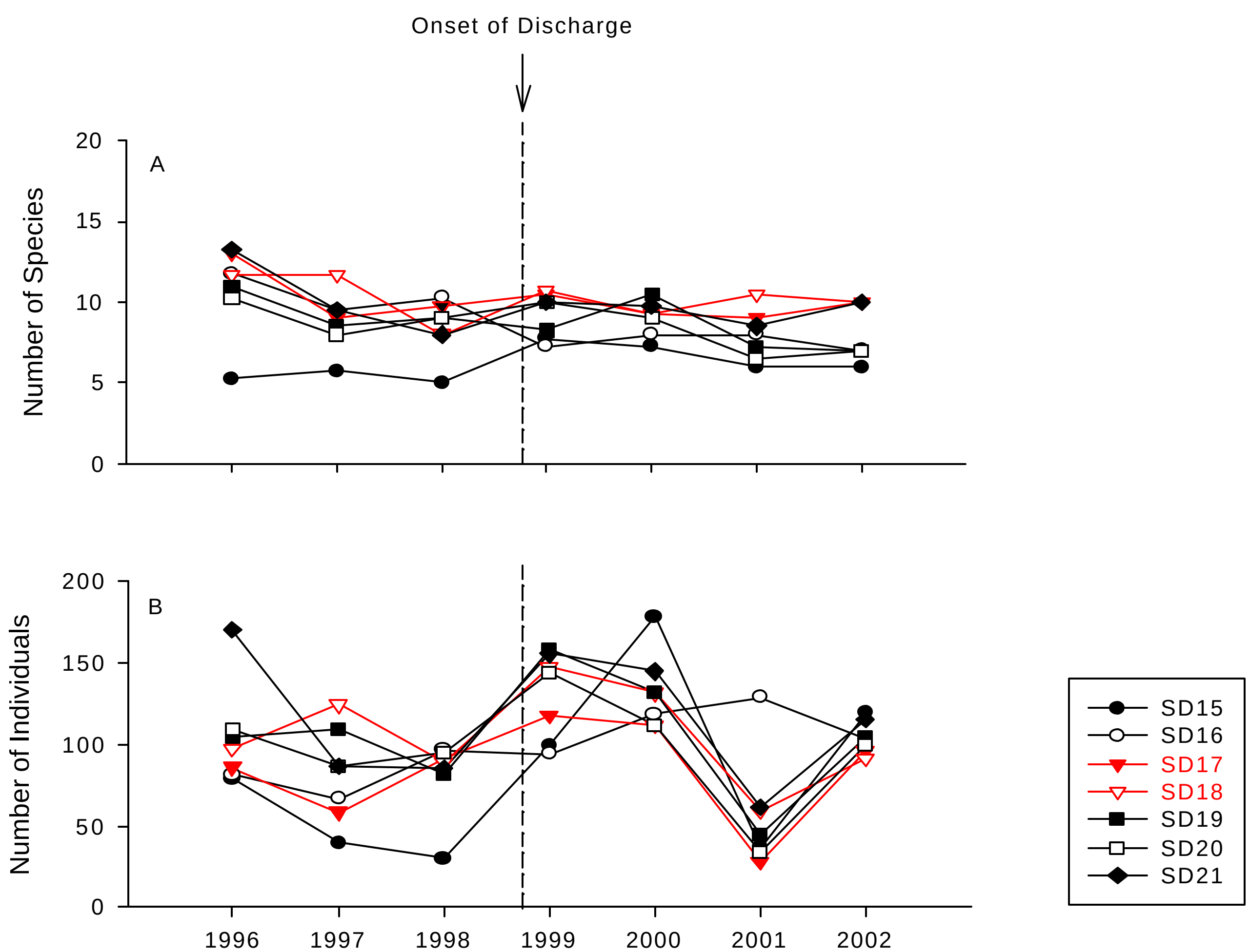



**Figure 6.2**
Annual mean number of fish species and abundance per station, 1996 through 2002.

infauna assemblages often found in this area (station I-3, see Chapters 4 and 5). No patterns were evident that suggest changes in the fish assemblages were associated with the initiation of the discharge.

### Physical Abnormalities and Parasitism

The presence of physical abnormalities or external parasites was rare among the fishes collected in 2002. Ambicoloration was found on the gill cover of a single hornyhead turbot collected at station SD16 in April. The overall rate of parasitism was low (0.34%). External parasites were found on just five fish, including two hornyhead turbots, as well as a California skate, a Pacific sanddab and a speckled sanddab. Additional parasites included the presence of an ectoparasitic isopod, *Elthusa vulgaris*, in several trawls. This isopod becomes detached from its host during sorting, therefore it is unknown which fish were actually parasitized. Although *E. vulgaris* occurs on a wide variety of fish species in southern California, it is especially common on sanddabs and California lizardfish, where it may reach infestation rates of 3% and 80%, respectively (Brusca 1978, 1981).

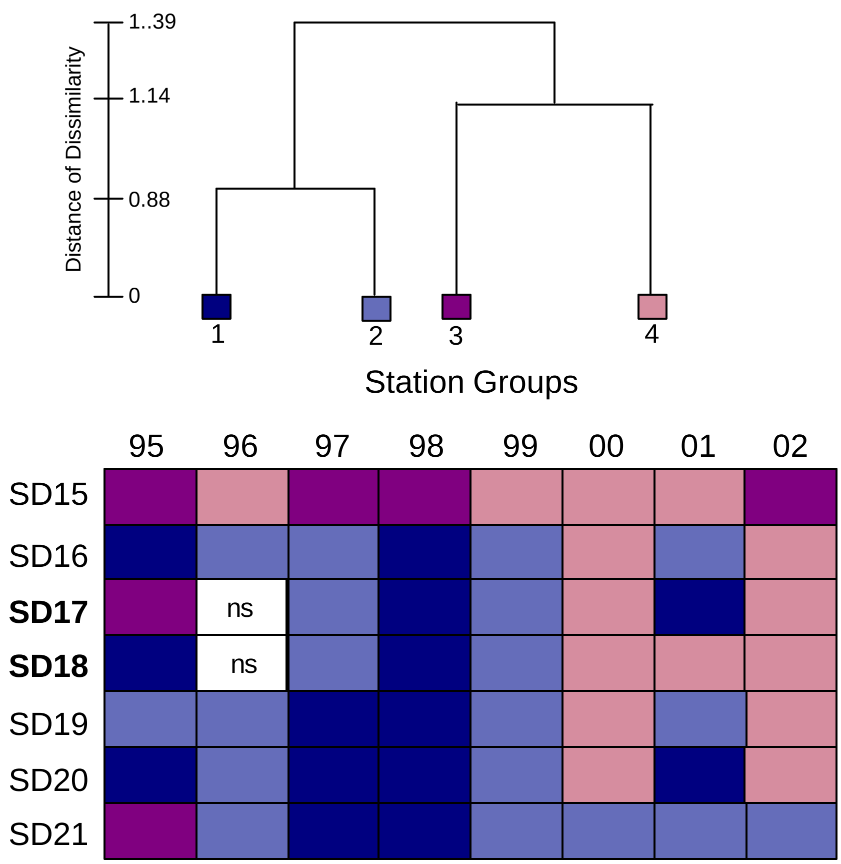



**Figure 6.3**
Results of classification analysis of demersal fish collected at stations SD15 - SD21 during October between 1995 and 2002. Data are presented as a dendrogram of major station groups and a matrix showing distribution over time.

## Table 6.3

Ten most abundant and frequently occurring fish species among the four main SBOO station cluster groups.The three most abundant species in each station group are indicated in bold type.

| | SG1 | SG2 | SG3 | SG4 |
|---|---|---|---|---|
| Number of hauls | 14 | 19 | 6 | 15 |
| Mean no. of species per haul | 8 | 10 | 5 | 7 |
| Mean no. of individuals per haul | 72 | 143 | 27 | 73 |
| **Species** | **Mean Abundance** | | | |
| **Speckled sanddab** | **30.3** | **79.3** | **20.7** | **57.1** |
| **California lizardfish** | **22.1** | 5.1 | **2.7** | 1.0 |
| **Longfin sanddab** | **9.2** | **12.1** | **1.2** | 1.4 |
| California tonguefish | 2.5 | 3.8 | . | 0.1 |
| **California scorpionfish** | 1.9 | 1.8 | 0.7 | **4.5** |
| Hornyhead turbot | 1.6 | 4.1 | 0.7 | 2.3 |
| Californa halibut | 1.2 | 1.1 | . | 0.2 |
| Fantail sole | 0.7 | 1.7 | . | 0.7 |
| Pacific sanddab | 0.6 | . | . | . |
| **Spotted turbot** | 0.4 | 1.6 | 0.7 | **2.6** |
| Bigmouth sole | 0.4 | 0.5 | . | 0.6 |
| English sole | 0.1 | 0.7 | . | 0.1 |
| Diamond turbot | 0.1 | 0.1 | 0.2 | 0.1 |
| Yellowchin sculpin | 0.1 | 0.9 | 0.2 | 0.1 |
| Thornback | 0.1 | . | 0.5 | . |
| Queenfish | . | 3.4 | . | . |
| Northern anchovy | . | 2.1 | . | . |
| Specklefin midshipman | . | 0.1 | . | 0.5 |
| Curlfin sole | . | 0.1 | . | 0.3 |
| Roughback sculpin | . | . | . | 0.5 |
| Unidentified flatfish | . | . | . | 0.5 |
| **White croaker** | . | **21.7** | . | . |

### Invertebrate Community

A total of 1,521 megabenthic invertebrates (~ 54/trawl) were collected during 2002, representing 55 taxa (Appendix B.2). The sea star *Astropecten verrilli* was the most abundant and most frequently captured species. This species was captured in 96% of the trawls and accounted for 48% of the total invertebrate catch (Table 6.4). Other species that occurred in at least 45% of the trawls included the sea urchin *Lytechinus pictus,* the shrimp *Crangon nigromaculata* and the crab *Pyromaia tuberculata*.

As with the fish, invertebrate community parameters varied among the stations and between surveys during the year (Table 6.5). In 2002, species richness ranged from 1 to 13 species per haul, with the number of species collected at a station frequently doubling (or being halved) from one survey to the next (e.g., stations SD16, SD18, SD20). Abundance values also varied greatly, ranging from 8 to 173 individuals per haul. The abundance at SD18 had the greatest range of any station, from 32 individuals in April to 173 in October. The abundance values in both July and October were primarily high due to large catches of *Lytechinus pictus.* Biomass values

## Table 6.4

Megabenthic invertebrate species collected in 28 trawls in the SBOO region during 2002. Data for each species are expressed as: (1) percent abundance (PA); (2) frequency of occurrence (FO); (3) mean abundance per haul (MAH); and (4) mean abundance per occurrence (MAO).

| Species | PA | FO | MAH | MAO | Species | PA | FO | MAH | MAO |
|---|---|---|---|---|---|---|---|---|---|
| *Astropecten verrilli* | 48 | 96 | 26 | 27 | *Crangon alba* | <1 | 4 | <1 | 2 |
| *Lytechinus pictus* | 17 | 46 | 9 | 20 | *Heptacarpus taylori* | <1 | 4 | <1 | 2 |
| *Crangon nigromaculata* | 9 | 68 | 5 | 7 | *Loxorhynchus crispatus* | <1 | 7 | <1 | 1 |
| *Astropecten* sp | 5 | 7 | 3 | 35 | *Megastraea undosa* | <1 | 7 | <1 | 1 |
| *Heptacarpus palpator* | 3 | 7 | 1 | 21 | *Paguristes bakeri* | <1 | 7 | <1 | 1 |
| *Dendraster terminalis* | 2 | 21 | 1 | 6 | *Platymera gaudichaudii* | <1 | 4 | <1 | 2 |
| *Heterocrypta occidentalis* | 2 | 39 | 1 | 3 | *Podochela hemphillii* | <1 | 7 | <1 | 1 |
| *Pyromaia tuberculata* | 2 | 46 | 1 | 2 | PORIFERA | <1 | 7 | <1 | 1 |
| *Philine auriformis* | 2 | 11 | 1 | 8 | *Acanthoptilum* sp | <1 | 4 | <1 | 1 |
| *Loligo opalescens* | 1 | 4 | 1 | 20 | *Astropecten armatus* | <1 | 4 | <1 | 1 |
| *Pisaster brevispinus* | 1 | 39 | 1 | 2 | *Calliostoma gloriosum* | <1 | 4 | <1 | 1 |
| *Kelletia kelletii* | 1 | 25 | 1 | 2 | *Cancer gracilis* | <1 | 4 | <1 | 1 |
| HIRUDINEA | 1 | 11 | <1 | 3 | *Cancer jordani* | <1 | 4 | <1 | 1 |
| *Heptacarpus stimpsoni* | 1 | 18 | <1 | 2 | *Cancer* sp | <1 | 4 | <1 | 1 |
| *Acanthodoris brunnea* | <1 | 14 | <1 | 2 | *Crossata californica* | <1 | 4 | <1 | 1 |
| *Hemisquilla ensigera californiensis* | <1 | 21 | <1 | 1 | *Dendronotus frondosus* | <1 | 4 | <1 | 1 |
| *Loxorhynchus grandis* | <1 | 21 | <1 | 1 | *Halosydna latior* | <1 | 4 | <1 | 1 |
| *Crangon alaskensis* | <1 | 14 | <1 | 1 | *Leptopecten latiauratus* | <1 | 4 | <1 | 1 |
| *Elthusa vulgaris* | <1 | 18 | <1 | 1 | *Mitra idea* | <1 | 4 | <1 | 1 |
| *Euspira lewisii* | <1 | 18 | <1 | 1 | *Nassarius perpinguis* | <1 | 4 | <1 | 1 |
| *Cancer anthonyi* | <1 | 14 | <1 | 1 | *Neverita reclusiana* | <1 | 4 | <1 | 1 |
| *Luidia armata* | <1 | 11 | <1 | 1 | *Octopus rubescens* | <1 | 4 | <1 | 1 |
| *Luidia foliolata* | <1 | 14 | <1 | 1 | *Octopus* sp | <1 | 4 | <1 | 1 |
| *Pagurus spilocarpus* | <1 | 14 | <1 | 1 | *Pteropurpura vokesae* | <1 | 4 | <1 | 1 |
| *Arctonoe pulchra* | <1 | 4 | <1 | 3 | *Randallia ornata* | <1 | 4 | <1 | 1 |
| *Calliostoma canaliculatum* | <1 | 11 | <1 | 1 | *Strongylocentrotus purpuratus* | <1 | 4 | <1 | 1 |
| *Ophiothrix spiculata* | <1 | 7 | <1 | 2 | *Thesea* sp B | <1 | 4 | <1 | 1 |
| *Archidoris montereyensis* | <1 | 7 | <1 | 1 | | | | | |

## Table 6.5

Summary of megabenthic invertebrate community parameters for SBOO stations sampled during 2002. Data are expressed as means and standard deviations for number of species, abundance, diversity (H') and biomass (kg, wet weight); n = 4.

| Parameter | Station | Jan | Apr | Jul | Oct | Mean | SD |
|---|---|---|---|---|---|---|---|
| No. of Species | SD15 | 13 | 9 | 6 | 6 | 9 | 3 |
| | SD16 | 7 | 10 | 5 | 10 | 8 | 2 |
| | SD17 | 6 | 8 | 12 | 11 | 9 | 3 |
| | SD18 | 7 | 6 | 10 | 5 | 7 | 2 |
| | SD19 | 7 | 8 | 6 | 5 | 7 | 1 |
| | SD20 | 6 | 7 | 1 | 5 | 5 | 3 |
| | SD21 | 4 | 10 | 9 | 9 | 8 | 3 |
| | Survey Mean | 7 | 8 | 7 | 7 | | |
| | Survey SD | 3 | 1 | 4 | 3 | | |
| No. of Individuals | SD15 | 66 | 70 | 52 | 45 | 58 | 12 |
| | SD16 | 42 | 37 | 29 | 44 | 38 | 7 |
| | SD17 | 44 | 67 | 93 | 43 | 62 | 24 |
| | SD18 | 53 | 32 | 121 | 173 | 95 | 65 |
| | SD19 | 54 | 87 | 76 | 49 | 67 | 18 |
| | SD20 | 15 | 50 | 53 | 33 | 38 | 18 |
| | SD21 | 8 | 27 | 19 | 39 | 23 | 13 |
| | Survey Mean | 40 | 53 | 63 | 61 | | |
| | Survey SD | 21 | 22 | 36 | 50 | | |
| Diversity (H') | SD15 | 1.9 | 1.1 | 0.5 | 0.7 | 1.0 | 0.6 |
| | SD16 | 1.2 | 1.8 | 1.0 | 1.5 | 1.4 | 0.3 |
| | SD17 | 1.3 | 0.7 | 1.1 | 1.9 | 1.3 | 0.5 |
| | SD18 | 1.4 | 1.2 | 1.2 | 0.7 | 1.1 | 0.3 |
| | SD19 | 1.0 | 1.2 | 0.6 | 0.5 | 0.8 | 0.3 |
| | SD20 | 1.2 | 1.2 | 0.0 | 0.9 | 0.8 | 0.6 |
| | SD21 | 1.1 | 1.9 | 2.1 | 1.8 | 1.7 | 0.4 |
| | Survery Mean | 1.3 | 1.3 | 1.1 | 1.1 | | |
| | Survey SD | 0.3 | 0.4 | 0.4 | 0.6 | | |
| Biomass | SD15 | 0.2 | 0.8 | 0.2 | 2.4 | 0.9 | 1.0 |
| | SD16 | 0.7 | 4.6 | 1.8 | 0.7 | 2.0 | 1.8 |
| | SD17 | 0.1 | 0.2 | 1.4 | 0.5 | 0.6 | 0.6 |
| | SD18 | 0.4 | 0.1 | 0.3 | 0.6 | 0.4 | 0.2 |
| | SD19 | 0.3 | 1.2 | 2.6 | 3.0 | 1.8 | 1.3 |
| | SD20 | 1.1 | 1.2 | 0.2 | 0.1 | 0.7 | 0.6 |
| | SD21 | 1.4 | 1.9 | 4.8 | 1.0 | 2.3 | 1.7 |
| | Survey Mean | 0.6 | 1.4 | 1.6 | 1.2 | | |
| | Survey SD | 0.5 | 1.5 | 1.7 | 1.1 | | |

were also somewhat variable, but in contrast to abundance, the hauls with the greatest biomass were due to a few heavy individuals of *Pisaster brevispinus*, collected at station SD16 in April, and SD21 in July.

Megabenthic invertebrate community structure has also varied in the South Bay area since 1996 (Figure 6.4). Although species richness has remained relatively consistent, abundances have fluctuated substantially over the years, with annual values averaging between 7-273 individuals per station. This wide range of values generally reflects differences in the populations of the dominant species, especially the echinoderms *Astropecten verrilli*, *Lytechinus pictus*, and *Dendraster terminalis*. For example, the high abundances recorded at SD17 in 1996 and SD15 in 1996 and 1997 were due to large hauls of *Astropecten verrilli* and *Lytechinus pictus*, while the high abundances at SD15 in 1998 and 1999 were due to large hauls of *Dendraster terminalis*. None of the observed variability in the invertebrate communities was associated with the initiation of discharge from the South Bay outfall.

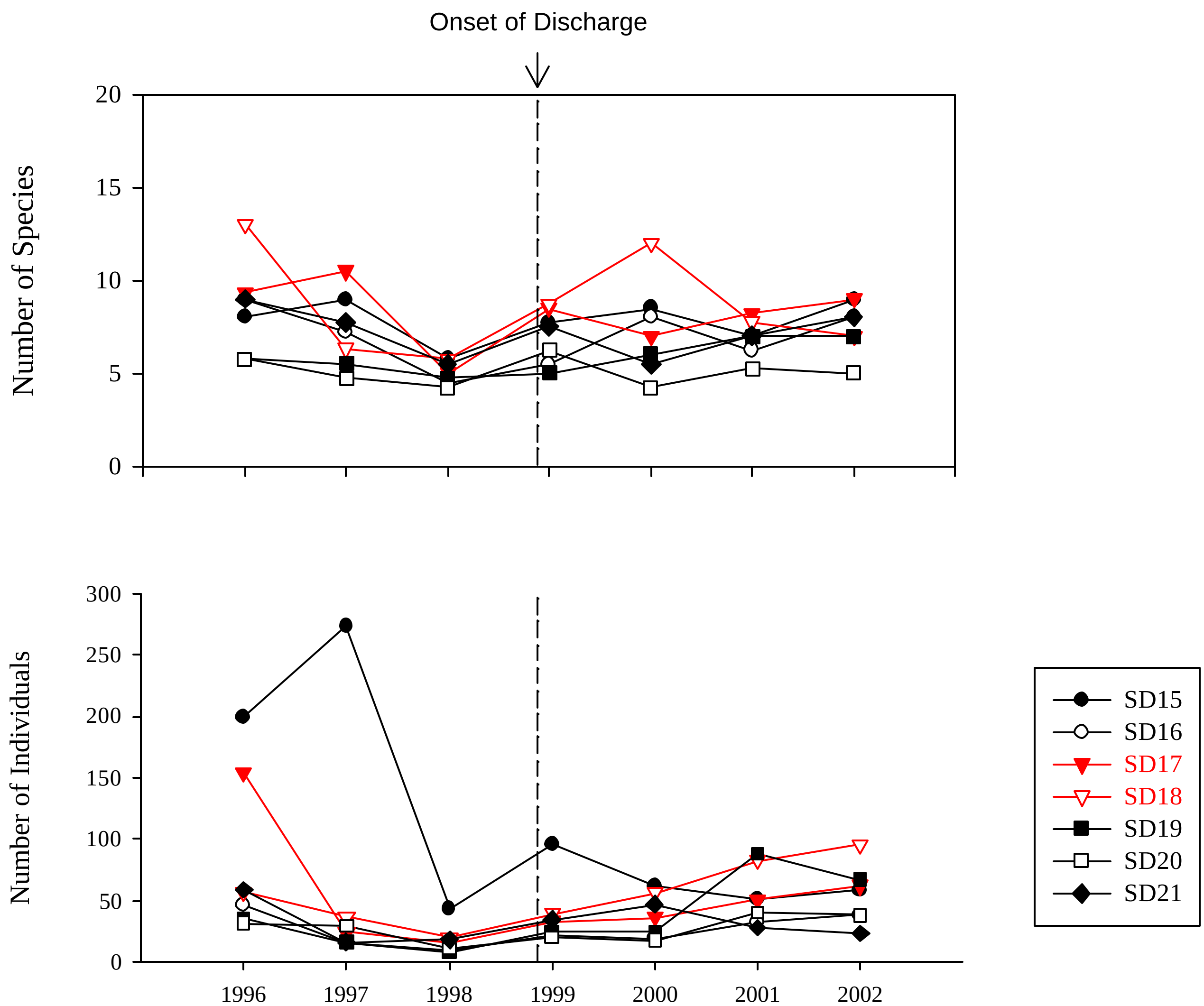



**Figure 6.4**

Annual mean number of megabenthic invertebrate species and abundance per station, 1996 through 2002.

Ordination and classification of sites discriminated between four major cluster groups, or megabenthic assemblages (Figure 6.5). These assemblages show no clear temporal pattern and generally reflect different numbers of the more common species, such as *Lytechinus pictus, Astropecten verrilli, Heterocrypta occidentalis* and *Philine auriformis* (Table 6.6). For example, station group SG1 had substantially higher numbers of *Lytenchinus pictus* and *Astropecten verrilli* than SG2 and SG3. Moreover, the patchy nature of some of these dominant organisms like *Lytechinus pictus* and *Astropecten verrill* caused SD17, SD18 and SD19 to move in to and out of the SG1 cluster group. As with fish, however, the fairly localized assemblage of station SD15 made it the most consistent member of this station group. Station SD15 had somewhat distinct fish and invertebrate assemblages during several years. The distinct assemblages found at this station are likely due to the sandy sediments and unique benthic infauna assemblages often found in this area (station I-3, see Chapters 4 and 5). Station group 4 (SG4) was also unique in that it consisted solely of invertebrates collected at station SD21 in October 1996, which included only single occurrences of four species. There was no evidence of temporal or spatial patterns to suggest that changes in the invertebrate assemblages were associated with the initiation of the discharge.

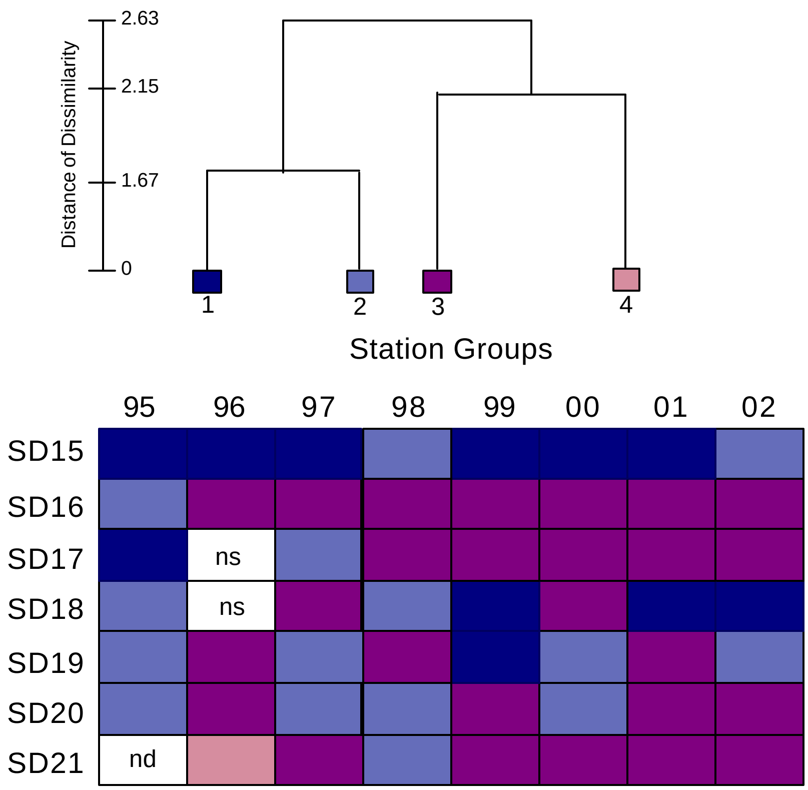



**Figure 6.5**
Results of classification analysis of megabenthic invertebrates collected at stations SD15 - SD21 during October between 1995 and 2002. Data are presented as a dendrogram of major station groups and a matrix showing distribution over time.

## Table 6.6

Ten most abundant and frequently occurring invertebrates species among the four main SBOO station cluster groups. The three most abundant species in each station group are indicated in bold type.

| | SG1 | SG2 | SG3 | SG4 |
|---|---|---|---|---|
| Number of hauls | 11 | 15 | 26 | 1 |
| Mean no. of species per haul | 8 | 6 | 7 | 4 |
| Mean no of Individuals per haul | 150 | 18 | 36 | 4 |
| **Species** | **Mean Abundance** | | | |
| ***Lytechinus pictus*** | **80.8** | **1.4** | 1.8 | . |
| ***Astropecten verrilli*** | **55.2** | **8.6** | **13.3** | . |
| ***Crangon nigromaculata*** | **2.8** | 0.3 | 2.1 | **1.0** |
| *Dendraster terminalis* | 1.8 | 0.1 | <0.1 | . |
| *Lovenia cordiformis* | 1.4 | 0.3 | . | . |
| *Stylatula elongata* | 1.4 | . | <0.1 | . |
| *Randallia ornata* | 0.8 | . | 0.1 | . |
| *Loxorhynchus grandis* | 0.8 | 0.5 | 0.4 | . |
| ***Heterocrypta occidentalis*** | 0.8 | **2.0** | **6.3** | . |
| *Crangon alba* | 0.5 | . | . | . |
| *Luidia armata* | 0.5 | 0.4 | <0.1 | . |
| *Asterina miniata* | 0.2 | 0.5 | . | . |
| *Pyromaia tuberculata* | 0.2 | 0.2 | 1.2 | . |
| ***Philine auriformis*** | 0.2 | . | **4.7** | . |
| *Portunus xantusii* | 0.1 | 0.3 | . | . |
| *Paguristes ulreyi* | . | 0.5 | . | . |
| *Cancer antennarius* | . | 0.2 | 0.1 | . |
| *Arctonoe pulchra* | . | 0.3 | . | . |
| *Heptacarpus stimpsoni* | . | 0.2 | 1.4 | . |
| *Elthus vulgrais* | . | . | 0.3 | . |
| *Cancer* sp | . | . | 0.3 | . |
| *Pisaster brevispinus* | . | 0.3 | 0.9 | . |
| *Kelletia kelletii* | . | . | 0.3 | . |
| ***Hemisquilla ensigera californiensis*** | . | . | <0.1 | **1.0** |
| ***Octopus* sp** | . | . | <0.1 | **1.0** |
| ***Flabellina iodinea*** | . | . | . | **1.0** |

## SUMMARY & CONCLUSIONS

Fish assemblages surrounding the South Bay Ocean Outfall were dominated by speckled sanddabs during 2002. Other fish, such as the hornyhead turbot, spotted turbot, California halibut and California lizardfish were also collected frequently. The invertebrate assemblages were similarly dominated by a few, prominent species. The sea star *Astropecten verrilli* was the most abundant species, while the sea urchin *Lytechinus pictus*, the shrimp *Crangon nigromaculata* and the crab *Pyromaia tuberculata* were also common.

As in previous years, variation in both fish and megabenthic invertebrate communities among stations and between surveys in the region were generally due to population fluctuations of the dominant species mentioned above.

Demersal fish and megabenthic invertebrate communities are inherently variable, and these changes in community structure may be influenced by both anthropogenic and natural factors.

Anthropogenic influences include inputs from such things as ocean outfalls and storm drain runoff. Natural factors may include prey availability (Cross et al. 1985), bottom relief and sediment structure (Helvey and Smith 1985), and changes in water temperature associated with large scale oceanographic events such as El Niño (Karinen et al. 1985). The observed changes in the epibenthic assemblages were more likely due to natural factors, which can impact the migration of adult fish or the recruitment of juveniles into an area (Murawski 1993). Population fluctuations that affect station diversity and abundance may also be due to the mobile nature of many species (e.g., schools of fish or aggregations of urchins).

Overall, the monitoring data provided no evidence that the discharge of waste water from the South Bay Ocean Outfall in 2002 affected either the fish or megabenthic invertebrate communities in the region. Despite the variable structure of these assemblages, patterns of species diversity, abundance and biomass were similar at stations near the outfall and at those located further away. In addition, no changes have been found in these assemblages that correspond to the initiation of wastewater discharge. Furthermore, the absence of fin rot or other physical abnormalities on local fishes suggest that populations in the area continue to be healthy.

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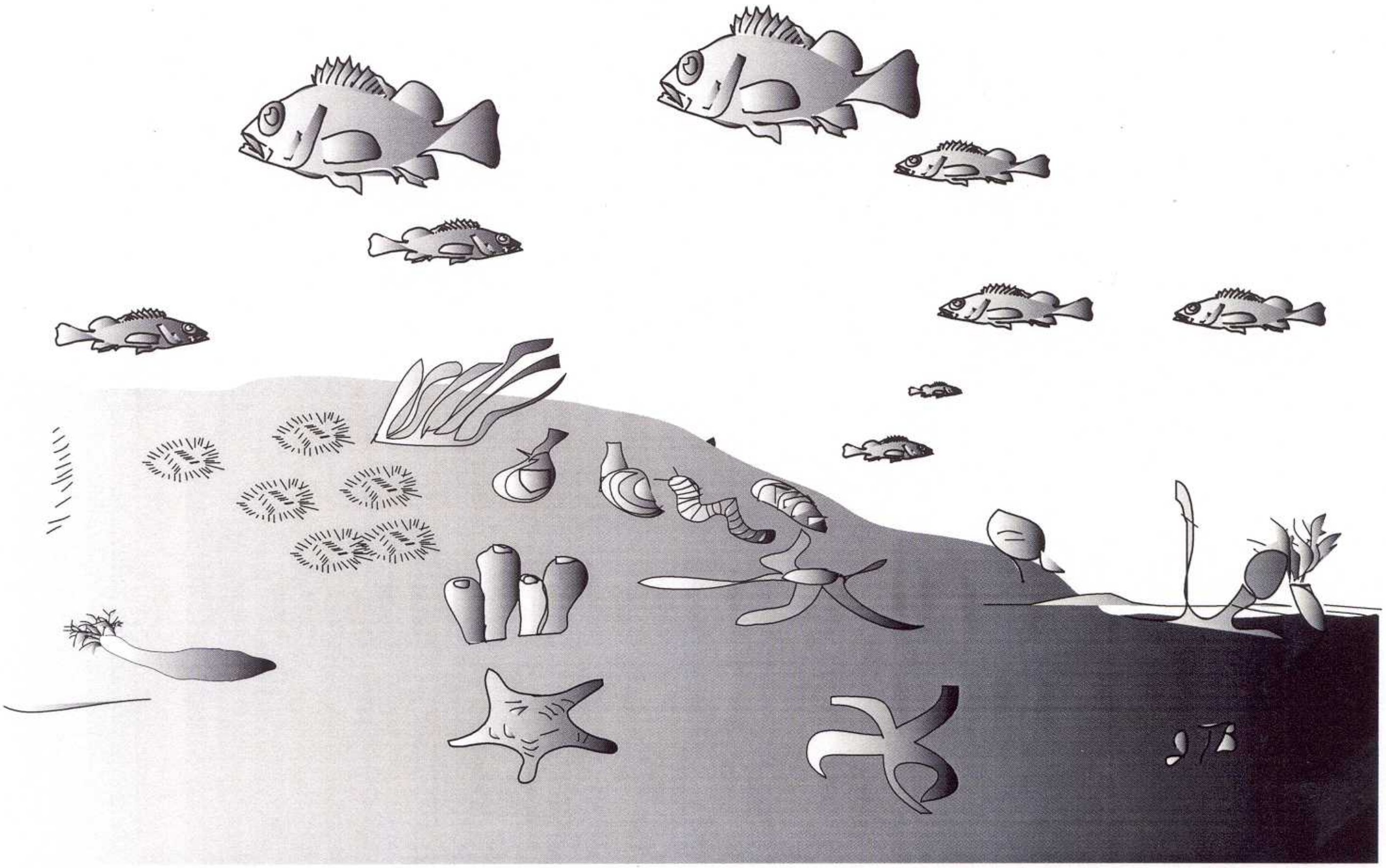
# Bioaccumulation of Contaminants in Fish Tissues



# Chapter 7

# Bioaccumulation of Contaminants in Fish Tissues

## INTRODUCTION

Bottom dwelling (i.e., demersal) fishes are collected as part of the South Bay Ocean Outfall (SBOO) monitoring program to assess the accumulation of contaminants in their tissues. The bioaccumulation of contaminants in fish occurs through biological uptake and retention of chemical contaminants derived from various exposure pathways (Tetra Tech 1985). Exposure routes for these fishes include the adsorption or absorption of dissolved chemical constituents from the water and the ingestion and assimilation of pollutants from food sources. They also accumulate pollutants by ingesting pollutant-containing suspended particulate matter or sediment particles. Demersal fish are useful in biomonitoring programs because of their proximity to bottom sediments. For this reason, levels of contaminants in tissues of demersal fish are often related to those found in the environment (Schiff and Allen 1997).

The bioaccumulation portion of the SBOO monitoring program consists of two components: (1) analysis of liver tissues from trawl-caught fishes; (2) analysis of muscle tissues from fishes collected by rig fishing. Fishes collected from trawls are considered representative of the demersal fish community, and certain species are targeted based on their ecological significance (i.e., prevalence in the community). Chemical analyses are performed using livers from these species because this is where contaminants are typically concentrated due to its physiological role and high lipid levels. In contrast, fishes targeted for collection by rig fishing represent a typical sport fisher's catch, and therefore have recreational and commercial importance. Muscle tissue is analyzed from these fish because it is the tissue most often consumed by humans and therefore the results are pertinent to human health concerns.

All muscle and liver samples were analyzed for contaminants as specified in the NPDES discharge permits for the SBOO monitoring program. This chapter presents the results of all tissue analyses that were performed during 2002.

## MATERIALS & METHODS

### Collection

Fishes were collected during the April and October surveys of 2002 at seven trawl stations and two rig fishing stations (Figure 7.1). Trawl-caught fishes were collected, measured and weighed following guidelines described in Chapter 6 of this report. Fishes targeted at the rig fishing sites were collected using rod and reel fishing tackle, and then measured and weighed following standard procedures (City of San Diego 2003). Only fish >11 cm standard length were retained for tissue analyses at all stations. After collection, fish collected at each station

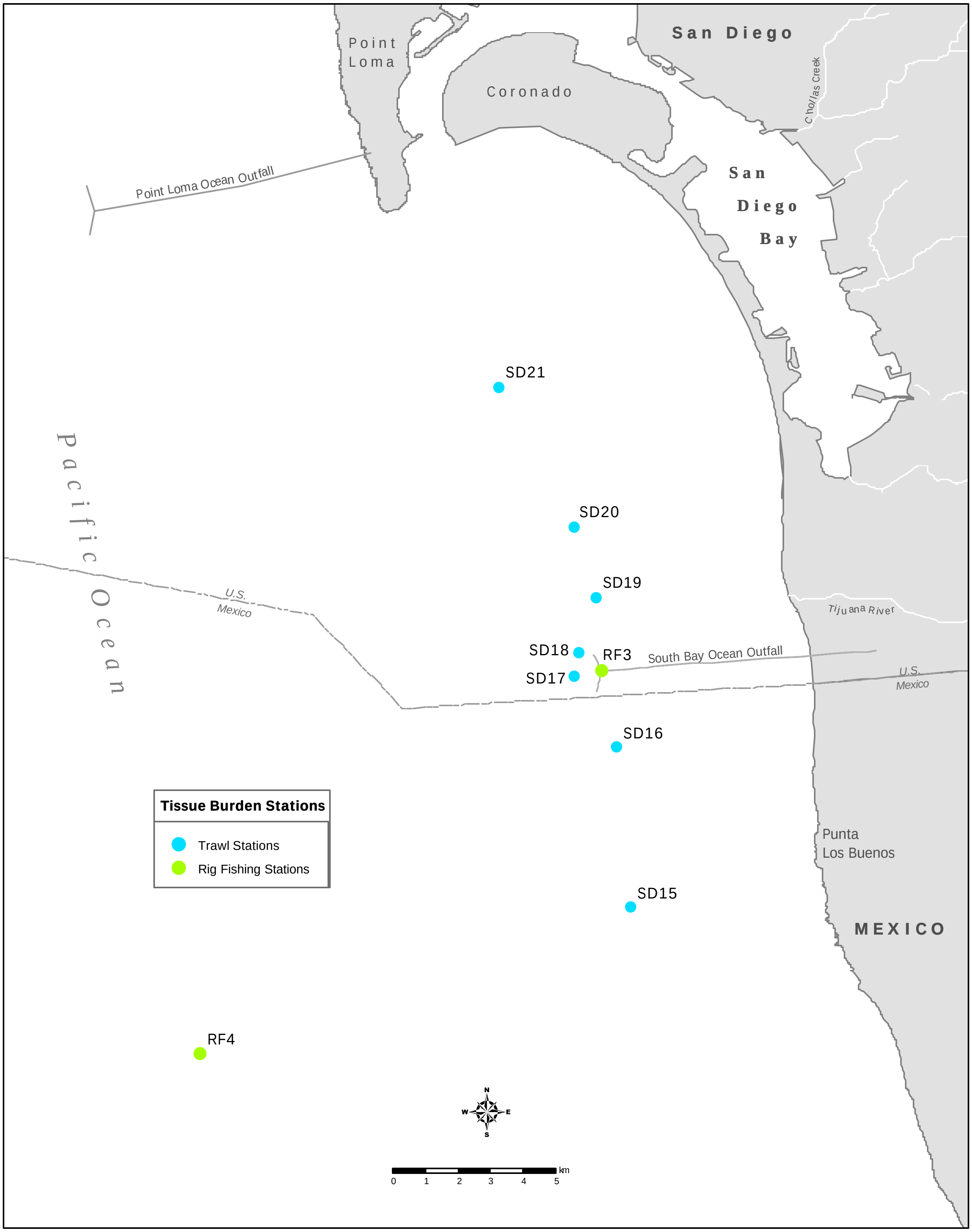



**Figure 7.1**
Otter trawl and rig fishing station locations for the South Bay Ocean Outfall Monitoring Program.

## Table 7.1

Species collected at each SBOO trawl and rig fishing station during April and October 2002; ns = samples not collected due to insufficient numbers of fish.

| Station | Rep 1 | Rep 2 | Rep 3 |
|---|---|---|---|
| *April 2002* | | | |
| SD15 | Hornyhead turbot | California scorpionfish | ns |
| SD16 | Longfin sanddab | Hornyhead turbot | California scorpionfish |
| SD17 | Longfin sanddab | Hornyhead turbot | California scorpionfish |
| SD18 | Longfin sanddab | Longfin sanddab | Hornyhead turbot* |
| SD19 | Longfin sanddab | Longfin sanddab | Hornyhead turbot |
| SD20 | Longfin sanddab* | English sole* | California scorpionfish* |
| SD21 | Longfin sanddab | Hornyhead turbot | Hornyhead turbot |
| RF3 | Barred sand bass | California scorpionfish | Vermilion rockfish |
| RF4 | California scorpionfish | California scorpionfish | California scorpionfish |
| *October 2002* | | | |
| SD15 | California scorpionfish | California scorpionfish | California scorpionfish |
| SD16 | California scorpionfish | California scorpionfish | California scorpionfish |
| SD17 | California scorpionfish | California scorpionfish | California scorpionfish |
| SD18 | Hornyhead turbot | Hornyhead turbot | ns |
| SD19 | Hornyhead turbot | California scorpionfish | ns |
| SD20 | Hornyhead turbot | Longfin sanddab | California scorpionfish |
| SD21 | California scorpionfish | Longfin sanddab | California scorpionfish |
| RF3 | Vermilion rockfish | Brown rockfish | Vermilion rockfish |
| RF4 | California scorpionfish | California scorpionfish | California scorpionfish |

* no mercury data available

were sorted into no more than three composite samples per station, each containing a minimum of three individuals. The fish were then wrapped in aluminum foil, labeled, put in ziplock bags, and placed on dry ice for transport to the Marine Biology laboratory freezer. The species that were analyzed from each station are summarized in Table 7.1.

### Tissue Processing and Chemical Analyses

All dissections were performed according to standard techniques for tissue analysis (see City of San Diego 2003). Each fish was partially defrosted and then cleaned with a paper towel to remove loose scales and excess mucus prior to dissection. The standard length (cm) and weight (g) of each fish were recorded (Appendix C.1). Dissections were carried out on Teflon pads that were cleaned between samples. Tissue samples were then placed in glass jars, sealed, labeled and stored in a freezer at -20°C prior to chemical analyses. All samples were subsequently delivered to the City of San Diego Wastewater Chemistry Laboratory within seven days of dissection.

All tissue samples were analyzed for the NOAA National Status and Trends chemical constituents, specified by the contract under which this sampling was performed. These metals, chlorinated pesticides, PCBs and PAHs are listed in Appendix C.2. A summary of all parameters detected at each station during each survey is listed in Appendix C.3. Detected parameters include some that were determined to be present in a sample with high confidence (i.e., peaks are confirmed by mass-spectrometry), but at levels below the MDL. These were included in the data as estimated values. No PAHs were detected during 2002. A detailed description of the analytical protocols may be obtained from the City of San Diego Wastewater Chemistry Laboratory.

## RESULTS

### Contaminants in Liver Tissues

***Distribution among Species***

Aluminum, arsenic, cadmium, copper, iron, manganese, mercury, selenium and zinc occurred frequently in the liver tissues of all species sampled (Table 7.2). Each of these metals was detected in over 70% of the samples, although in highly variable concentrations. Chromium, nickel, antimony and silver were also detected, but much less frequently.

Several chlorinated pesticides were detected in fish liver tissues (Table 7.3). Total DDT (the sum of three DDT derivatives and their isomers) was found in all samples, with concentrations averaging from about 50 ppb in English sole to 5,600 ppb in California scorpionfish. Other detected pesticides included chlordane, BHC, hexachlorobenzene (HCB), heptachlor and nonachlor (trans and cis). Of these, HCB and trans nonachlor were the most common, occurring in >50% of the samples. Chlordane occurred primarily as alpha (cis) chlordane (26% detection rate) at concentrations ranging from 3.3 to 11 ppb. BHC (alpha and beta), gamma (trans) chlordane, and heptachlor occurred only once each, and in the same California scorpionfish sample. Cis nonachlor was also detected only once.

PCBs occurred in all samples from each species. Concentrations for the individual PCB congeners are listed separately in Appendix C.3. Total PCB concentrations (i.e., the sum of all congeners detected in a sample) were variable, ranging from 12.4 ppb to 823.6 ppb.

***Distribution among Stations***

Concentrations of the frequently detected metals in fish liver tissues varied across all stations (Figure 7.2). However, intraspecific comparisons between the stations closest to the discharge (SD17, SD18) and those farther away (SD15-SD16, SD19-SD21) suggest that there was no clear relationship with proximity to the outfall. Further, most liver tissue concentrations were close to or below the maximum concentrations detected in the same species prior to discharge.

DDT, trans nonachlor, HCB and PCBs were detected in fishes collected from all stations (Figure 7.3). As with the metals, there was no clear relationship between concentrations of these parameters and proximity to the outfall, and most values were close to or below the maximum concentrations detected in the same species prior to discharge.

## Table 7.2

Metals detected in liver samples from fish collected at SBOO trawl stations during 2002. Values are expressed as parts per million (ppm). N = number of detected values, nd = not detected, ns = not sampled.

| | Al | As | Cd | Cr | Cu | Fe | Mn | Hg* | Ni | Sb | Se | Ag | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ca. Scorpionfish | | | | | | | | | | | | | |
| N (out of 17) | 13 | 9 | 14 | 1 | 17 | 17 | 11 | 15 | 1 | 0 | 17 | 1 | 17 |
| Min | 4.5 | 1.5 | 0.4 | 0.4 | 12.1 | 63.3 | 0.32 | 0.070 | 0.98 | —- | 0.42 | 0.7 | 49.7 |
| Max | 37.4 | 7.4 | 4.5 | 0.4 | 81.1 | 410.0 | 0.85 | 0.404 | 0.98 | —- | 1.04 | 0.7 | 166.0 |
| Mean | 15.2 | 3.7 | 2.0 | 0.4 | 33.0 | 162.4 | 0.46 | 0.175 | 0.98 | —- | 0.80 | 0.7 | 102.6 |
| Hornyhead turbot | | | | | | | | | | | | | |
| N (out of 11) | 7 | 10 | 11 | 0 | 10 | 11 | 10 | 10 | 0 | 1 | 11 | 0 | 11 |
| Min | 3.4 | 1.4 | 1.7 | —- | 2.1 | 38.0 | 0.65 | 0.014 | —- | 88.2 | 0.38 | —- | 30.6 |
| Max | 27.8 | 11.6 | 11.2 | —- | 30.6 | 73.7 | 2.32 | 0.172 | —- | 88.2 | 0.89 | —- | 83.1 |
| Mean | 10.9 | 5.7 | 6.6 | —- | 8.7 | 53.5 | 1.58 | 0.105 | —- | 88.2 | 0.63 | —- | 46.9 |
| Longfin sanddab | | | | | | | | | | | | | |
| N (out of 10) | 7 | 9 | 8 | 1 | 10 | 10 | 10 | 9 | 1 | 0 | 10 | 3 | 10 |
| Min | 2.6 | 1.4 | 0.6 | 5.1 | 0.9 | 38.7 | 0.34 | 0.007 | 1.55 | —- | 0.75 | 0.7 | 15.8 |
| Max | 17.0 | 14.8 | 4.3 | 5.1 | 13.8 | 217.0 | 2.19 | 0.234 | 1.55 | —- | 1.42 | 0.8 | 29.0 |
| Mean | 7.7 | 8.2 | 1.8 | 5.1 | 6.9 | 127.8 | 1.43 | 0.145 | 1.55 | —- | 0.97 | 0.7 | 23.9 |
| English sole | | | | | | | | | | | | | |
| N (out of 1) | 1 | 1 | 1 | 0 | 1 | 1 | 1 | ns | 0 | 0 | 1 | 0 | 1 |
| Min | 3.9 | 20.8 | 0.8 | —- | 7.6 | 256.0 | 2.63 | —- | —- | —- | 0.77 | —- | 44.1 |
| Max | 3.9 | 20.8 | 0.8 | —- | 7.6 | 256.0 | 2.63 | —- | —- | —- | 0.77 | —- | 44.1 |
| Mean | 3.9 | 20.8 | 0.8 | —- | 7.6 | 256.0 | 2.63 | —- | —- | —- | 0.77 | —- | 44.1 |
| ALL SPECIES | | | | | | | | | | | | | |
| % Detect. | 72 | 74 | 87 | 5 | 97 | 100 | 82 | 97 | 5 | 3 | 100 | 10 | 100 |

* sample size for mercury is one less for each species

## Table 7.3

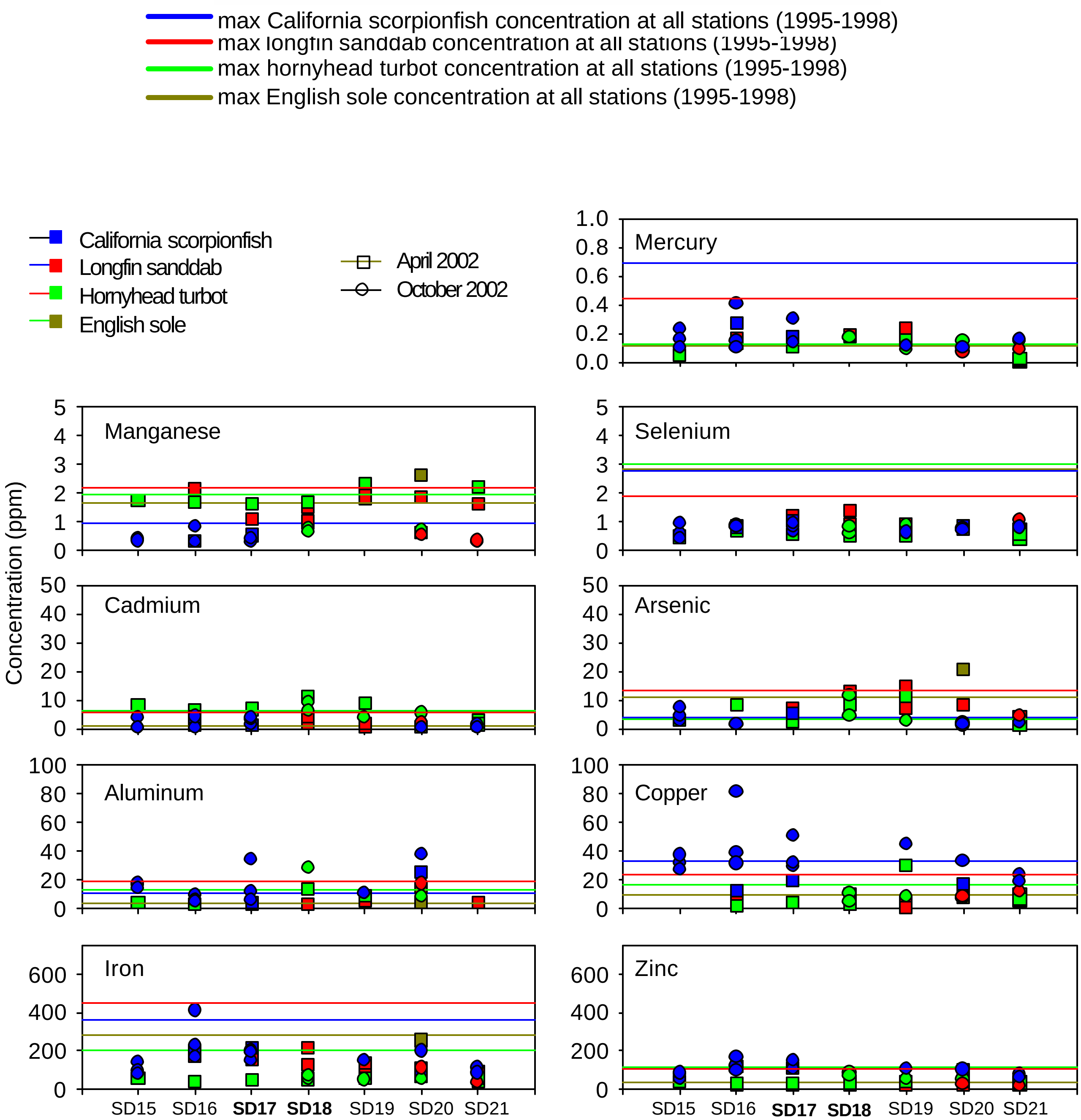
Chlorinated pesticides, PCBs, and lipids detected in liver samples from fish collected at SBOO trawl stations during 2002. Values are expressed as parts per billion (ppb) for all parameters except lipids, which are presented as percent weight (% wt). N = number of detected values, nd = not detected.

| | Chlorinated Pesticides | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chlordane | | BHC | | | Hepta- | Nonachlor | | Total | Total | |
| | Alpha | Gamma | Alpha | Beta | HCB | chlor | Trans | Cis | DDT | PCB | Lipids |
| Ca. Scorpionfish | | | | | | | | | | | |
| N (out of 17) | 4 | 1 | 1 | 1 | 17 | 1 | 13 | 0 | 17 | 17 | 17 |
| Min | 3.3 | 6 | 20 | 31 | 1 | 8.6 | 6.3 | —- | 112.3 | 36.8 | 15.9 |
| Max | 8.5 | 6 | 20 | 31 | 4.7 | 8.6 | 22.0 | —- | 5600.7 | 823.6 | 45.4 |
| Mean | 5.2 | 6 | 20 | 31 | 2.7 | 8.6 | 10.3 | —- | 837.1 | 277.2 | 28.1 |
| Hornyhead turbot | | | | | | | | | | | |
| N (out of 11) | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 11 | 11 | 11 |
| Min | —- | —- | —- | —- | 0.7 | —- | —- | —- | 58.0 | 12.4 | 3.6 |
| Max | —- | —- | —- | —- | 1.5 | —- | —- | —- | 386.4 | 152.7 | 25.8 |
| Mean | —- | —- | —- | —- | 1.2 | —- | —- | —- | 112.3 | 43.2 | 8.7 |
| Longfin sanddab | | | | | | | | | | | |
| N (out of 10) | 6 | 0 | 0 | 0 | 10 | 0 | 9 | 1 | 10 | 10 | 10 |
| Min | 5.1 | —- | —- | —- | 1.7 | —- | 4.3 | 11 | 516.6 | 265.2 | 4.7 |
| Max | 11.0 | —- | —- | —- | 3.4 | —- | 15.0 | 11 | 1598.7 | 686.6 | 43.2 |
| Mean | 8.2 | —- | —- | —- | 2.5 | —- | 10.6 | 11 | 1005.0 | 437.4 | 25.7 |
| English sole | | | | | | | | | | | |
| N (out of 1) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| Min | —- | —- | —- | —- | —- | —- | —- | —- | 49.4 | 25.4 | 3.31 |
| Max | —- | —- | —- | —- | —- | —- | —- | —- | 49.4 | 25.4 | 3.31 |
| Mean | —- | —- | —- | —- | —- | —- | —- | —- | 49.4 | 25.4 | 3.31 |
| ALL SPECIES | | | | | | | | | | | |
| % Dect. | 26 | 3 | 3 | 3 | 79 | 3 | 56 | 3 | 100 | 100 | |

### Contaminants in Muscle Tissues

To address human health concerns, concentrations of various constituents found in muscle tissue samples were compared to national and international limits and standards (Table 7.4). The United States Food and Drug Administration (FDA) has set mercury and total DDT limits for seafood that is to be sold for human consumption (Mearns et al. 1991). In addition, there are international standards for acceptable concentrations of various metals (Mearns et al. 1991). While many of these compounds were detected in the muscle tissues of fish collected as part of the SBOO monitoring program, only arsenic had concentrations that were higher than international standards.

In addition to addressing health concerns, spatial patterns were assessed for total DDT and total PCB, as well as all metals that occurred frequently in fish muscle tissue samples (Figure 7.4). Concentrations of these parameters were variable at both stations and no clear relationship with proximity to the outfall was evident; samples from




## Figure 7.2

Concentrations of frequently detected metals in liver tissues of fish collected from each trawl station during 2002. Note that only five samples were collected at station SD15, SD18 and SD19; otherwise missing data represent concentrations below detection limits. Reference lines are maximum values during the pre-discharge period (1995-1998). Stations closest to the discharge site are labeled in bold.

the nearfield station (RF3) had values similar to those of the farfield station (RF4). Further, most California scorpionfish and barred sand bass had values close to or below the maximum concentrations detected in the same species at RF3 prior to discharge.

## SUMMARY and CONCLUSIONS

Demersal fish collected around the South Bay Ocean Outfall during 2002 were characterized by contaminant values within the range of those reported previously for other fish assemblages in the Southern California Bight

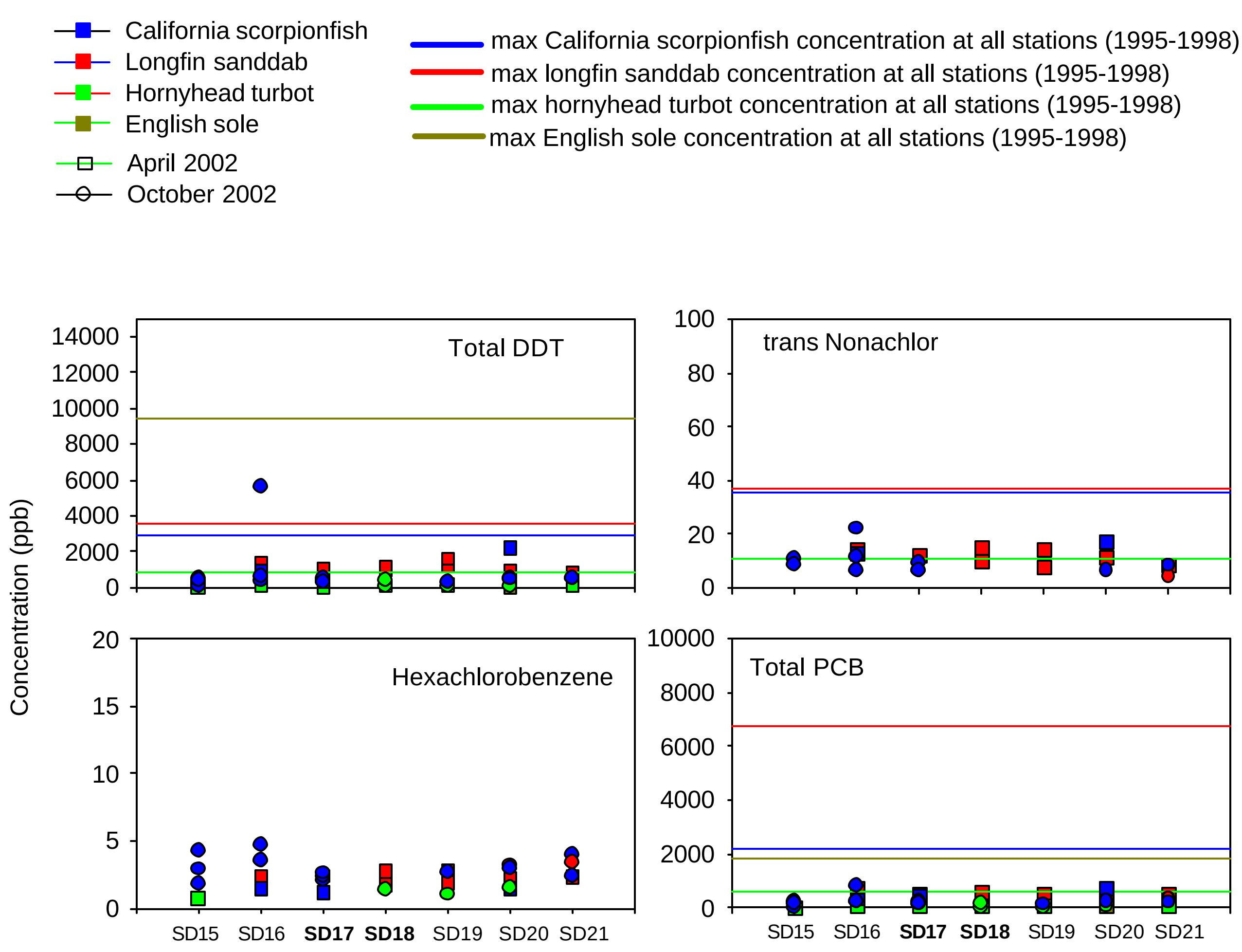



**Figure 7.3**
Concentrations of frequently detected chlorinated pesticides (total DDT, trans Nonachlor, hexachlorobenzene) and total PCBs in liver tissues of fish collected from each trawl station during 2002. Note that only five samples were collected at station SD15, SD18 and SD19; otherwise missing data represent concentrations below detection limits. Reference lines are maximum values during the pre-discharge period (1995-1998). Stations closest to the discharge site are labeled in bold.

## Table 7.4

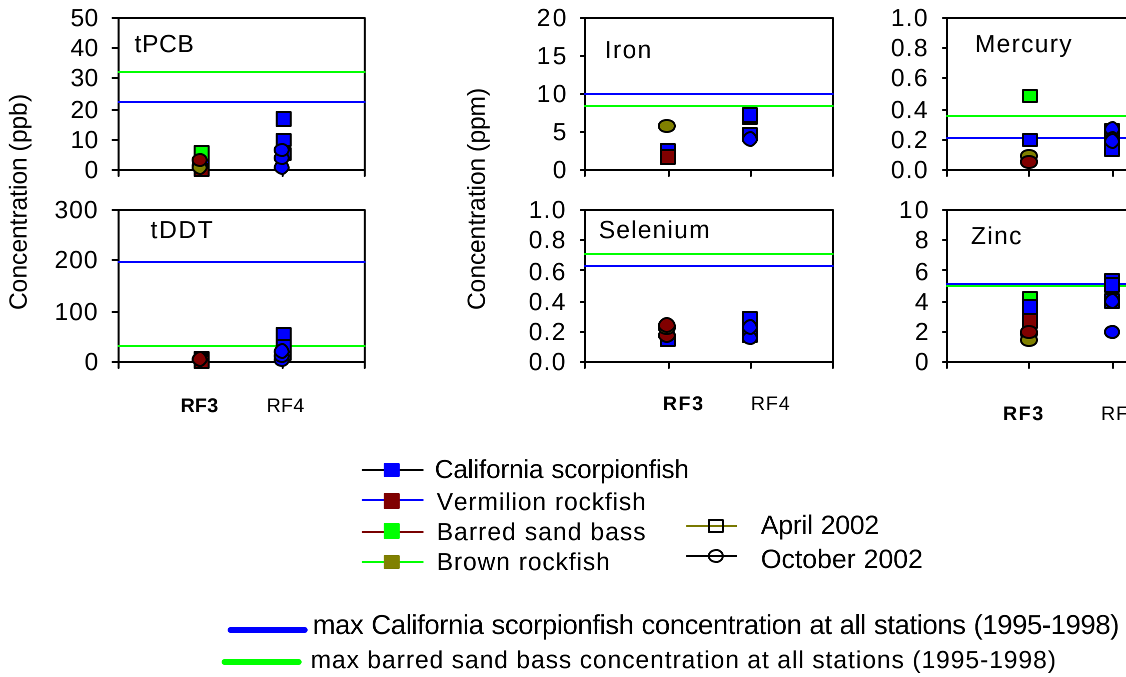
Concentrations of various metals and total DDT detected in muscle samples from fish collected at SBOO rig fishing stations during 2002. Values are parts per million (ppm) for all parameters. Data for each species are compared to U.S. FDA action limits and median international standards. Bolded values exceed these standards.

| | As | Cd | Cr | Cu | Pb | Hg | Se | Tn | Zn | tDDT |
|---|---|---|---|---|---|---|---|---|---|---|
| Ca. scorpionfish | | | | | | | | | | |
| N (out of 7) | 3 | 0 | 1 | 3 | 0 | 7 | 7 | 0 | 7 | 7 |
| Min | **1.9** | . | 0.32 | 0.77 | . | 0.138 | 0.15 | . | 1.9 | 0.0032 |
| Max | **2.5** | . | 0.32 | 2.74 | . | 0.265 | 0.29 | . | 5.3 | 0.0542 |
| Mean | **2.3** | . | 0.32 | 1.48 | . | 0.209 | 0.21 | . | 3.7 | 0.0205 |
| Vermilion rockfish | | | | | | | | | | |
| N (out of 3) | 2 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 3 | 3 |
| Min | 1.4 | . | . | . | . | 0.044 | 0.17 | . | 1.8 | 0.0013 |
| Max | **2.1** | . | . | . | . | 0.057 | 0.24 | . | 2.7 | 0.0050 |
| Mean | **1.8** | . | . | . | . | 0.050 | 0.21 | . | 2.2 | 0.0035 |
| Barred sand bass | | | | | | | | | | |
| N (out of 1) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| Min | . | . | . | . | . | 0.486 | . | . | 4.2 | 0.0068 |
| Max | . | . | . | . | . | 0.486 | . | . | 4.2 | 0.0068 |
| Mean | . | . | . | . | . | 0.486 | . | . | 4.2 | 0.0068 |
| Brown rockfish | | | | | | | | | | |
| N (out of 1) | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| Min | **2.4** | . | 0.33 | . | . | 0.085 | 0.22 | . | 1.4 | 0.0049 |
| Max | **2.4** | . | 0.33 | . | . | 0.085 | 0.22 | . | 1.4 | 0.0049 |
| Mean | **2.4** | . | 0.33 | . | . | 0.085 | 0.22 | . | 1.4 | 0.0049 |
| US FDA Action Limit* | | | | | | 1 | | | | 5 |
| Median International Standard* | 1.4 | 1.0 | 1.00 | 20 | 2 | 0.50 | 0.30 | 175 | 70 | 5 |

*From Table 2.3 in Mearns et al. (1991). USFDA action limit for total DDT is for fish muscle tissue. USFDA mercury action limits and all international standards are for shellfish, but are often applied to fish. All limits apply to the sale of seafood for human consumption.

(SCB) (see Mearns et al. 1991, City of San Diego 1996 - 2001a, Allen et al. 1998). In addition, concentrations of most contaminants were not substantially different from pre-discharge data (City of San Diego 2000b).

The frequent occurrence of metals and chlorinated hydrocarbons in SBOO fish tissues may be due to many factors. Mearns et al. (1991) described the distribution of several contaminants, including arsenic, mercury, DDT, and PCBs as being ubiquitous in the SCB. In fact, many metals occur naturally in the environment, although little information is available on their background levels in fish tissues. Brown et al. (1986) determined that no areas of the SCB are sufficiently free of chemical contaminants to be considered reference sites. This has been supported by more recent work regarding PCBs and DDTs (e.g., Allen et al. 1998). The lack of contaminant-free reference areas in the SCB clearly pertains to the South Bay region, as demonstrated by the presence of many contaminants in fish tissues prior to the discharge (City of San Diego 2000b).




## Figure 7.4

Concentrations of frequently detected metals, total DDT and total PCB in muscle tissues of fish collected from each rig fishing station during 2002. Missing data represent concentrations below detection limits. Reference lines are maximum values during the pre-discharge period (1995-1998) for California scorpionfish and barred sand bass. No vermilion or brown rockfish were collected during that period. The station closest to the discharge site is labeled in bold.

Other factors that affect the accumulation and distribution of contaminants include the physiology and life history of different fish species. For example, exposure to contaminants can vary greatly between species and among individuals of the same species depending on migration habits (Otway 1991). Fish may be exposed to contaminants in one highly contaminated area and then move into an area that is less contaminated. This is of particular concern for fishes collected in the vicinity of the SBOO, as there are many point and non-point sources that may contribute to contamination in the region. For example, some monitoring stations are located near the Tijuana River, San Diego Bay, and dredged materials disposal sites, and input from these sources may affect fish in nearby areas (see Appendix D, Figure D.3).

Overall, there was no evidence that fishes collected in 2002 were contaminated by the discharge of waste water from the South Bay Ocean Outfall. In addition, concentrations of mercury and DDT in muscle tissues from sport fish collected in the area were below FDA human consumption limits. Finally, there was no other indication of poor fish health in the region, such as the presence of fin rot or other physical anomalies (see Chapter 6).

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# Appendices

# Appendix A

## Supporting Data

## 2002 SBOO Stations

## Sediment Characteristics

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## Appendix A.1

Particle size statistics for SBOO sediments, January 2002 survey.

| Station | Mean Phi | Std. Dev. Phi | Median Phi | Skewness | Kurtosis | Coarse % | Sand % | Silt % | Clay % |
|---|---|---|---|---|---|---|---|---|---|
| ***19 m stations*** | | | | | | | | | |
| I-35 | 3.9 | 1.1 | 3.7 | 0.4 | 1.3 | 0.0 | 60.6 | 37.7 | 1.7 |
| I-34 | 0.5 | 0.9 | 0.1 | 0.6 | 0.9 | 46.7 | 53.3 | 0.0 | 0.0 |
| I-31 | 3.2 | 0.6 | 3.1 | 0.2 | 1.2 | 0.0 | 93.1 | 6.4 | 0.4 |
| I-23 | 3.2 | 0.8 | 3.2 | 0.3 | 1.5 | 0.0 | 89.2 | 10.0 | 0.8 |
| I-18 | 2.9 | 0.5 | 2.9 | 0.2 | 1.4 | 0.0 | 93.8 | 5.9 | 0.3 |
| I-10 | 2.9 | 0.7 | 2.9 | 0.1 | 1.1 | 0.0 | 91.7 | 7.8 | 0.5 |
| I-4 | 3.2 | 0.7 | 3.2 | 0.2 | 1.3 | 0.0 | 90.2 | 9.2 | 0.6 |
| ***28 m stations*** | | | | | | | | | |
| I-33 | 2.9 | 0.9 | 2.9 | 0.2 | 2.4 | 0.0 | 88.9 | 10.1 | 1.0 |
| I-30 | 3.4 | 0.8 | 3.4 | 0.2 | 1.5 | 0.0 | 83.9 | 15.1 | 0.9 |
| I-27 | 3.2 | 0.9 | 3.2 | 0.1 | 1.1 | 0.0 | 86.1 | 13.1 | 0.8 |
| I-22 | 3.3 | 0.9 | 3.2 | 0.3 | 1.6 | 0.0 | 85.0 | 14.2 | 0.8 |
| I-14 | 3.2 | 0.4 | 3.1 | 0.2 | 0.8 | 0.0 | 95.5 | 4.3 | 0.2 |
| I-15 | 1.5 | 0.6 | 1.5 | 0.1 | 1.0 | 0.0 | 99.4 | 0.6 | 0.0 |
| I-16 | 0.8 | 0.3 | 0.8 | 0.3 | 3.1 | 0.0 | 99.7 | 0.3 | 0.0 |
| I-12 | 3.1 | 0.8 | 3.0 | 0.3 | 1.3 | 1.7 | 87.3 | 10.4 | 0.6 |
| I-9 | 3.3 | 0.8 | 3.2 | 0.3 | 1.3 | 0.0 | 84.2 | 15.0 | 0.8 |
| I-2 | 1.6 | 0.6 | 1.7 | -0.1 | 1.0 | 0.0 | 99.0 | 1.0 | 0.0 |
| I-6 | 0.9 | 0.7 | 0.8 | 0.3 | 1.4 | 3.7 | 96.3 | 0.0 | 0.0 |
| I-3 | 1.6 | 0.6 | 1.5 | 0.1 | 1.0 | 0.0 | 99.7 | 0.3 | 0.0 |
| ***38 m stations*** | | | | | | | | | |
| I-29 | 3.7 | 1.0 | 3.7 | 0.3 | 1.8 | 0.0 | 67.8 | 30.3 | 1.9 |
| I-21 | 0.8 | 0.8 | 0.8 | 0.1 | 1.4 | 15.0 | 85.0 | 0.0 | 0.0 |
| I-13 | 1.1 | 0.6 | 1.0 | 0.5 | 1.7 | 0.0 | 100.0 | 0.0 | 0.0 |
| I-8 | 1.3 | 0.7 | 1.1 | 0.6 | 1.6 | 0.0 | 100.0 | 0.0 | 0.0 |
| ***55 m stations*** | | | | | | | | | |
| I-28 | 3.8 | 2.2 | 3.7 | 0.1 | 1.5 | 14.5 | 46.2 | 35.1 | 4.1 |
| I-20 | 1.1 | 1.2 | 0.5 | 0.6 | 1.2 | 21.9 | 78.1 | 0.0 | 0.0 |
| I-7 | 0.9 | 0.7 | 0.7 | 0.3 | 1.1 | 5.5 | 94.5 | 0.0 | 0.0 |
| I-1 | 2.9 | 1.0 | 2.9 | 0.3 | 3.2 | 0.0 | 87.6 | 11.2 | 1.2 |

## Appendix A.1

Particle size statistics for SBOO sediments, July 2002 survey.

| Station | Mean Phi | Std. Dev. Phi | Median Phi | Skewness | Kurtosis | Coarse % | Sand % | Silt % | Clay % |
|---|---|---|---|---|---|---|---|---|---|
| ***19 m stations*** | | | | | | | | | |
| I-35 | 3.7 | 1.2 | 3.6 | 0.3 | 1.4 | 0.0 | 65.4 | 32.8 | 1.8 |
| I-34 | 1.7 | 0.7 | 1.7 | 0.0 | 1.0 | 0.7 | 98.9 | 0.4 | 0.0 |
| I-31 | 3.2 | 0.6 | 3.2 | 0.0 | 0.7 | 0.0 | 92.6 | 6.9 | 0.5 |
| I-23 | 3.2 | 0.7 | 3.2 | 0.2 | 1.4 | 0.0 | 89.6 | 9.6 | 0.8 |
| I-18 | 3.3 | 0.7 | 3.3 | 0.0 | 0.9 | 0.0 | 90.0 | 9.4 | 0.6 |
| I-10 | 3.2 | 0.7 | 3.2 | 0.1 | 1.0 | 0.0 | 90.0 | 9.3 | 0.7 |
| I-4 | 0.7 | 0.6 | 0.7 | 0.4 | 3.6 | 0.3 | 98.8 | 0.9 | 0.0 |
| ***28 m stations*** | | | | | | | | | |
| I-33 | 3.1 | 0.9 | 3.0 | 0.4 | 2.9 | 0.0 | 87.3 | 11.4 | 1.3 |
| I-30 | 3.2 | 1.0 | 3.2 | 0.1 | 1.1 | 0.0 | 84.7 | 14.4 | 0.9 |
| I-27 | 3.1 | 1.0 | 3.1 | 0.1 | 1.1 | 0.0 | 85.3 | 13.9 | 0.8 |
| I-22 | 3.2 | 0.8 | 3.2 | 0.2 | 1.5 | 0.0 | 86.8 | 12.3 | 0.8 |
| I-14 | 3.3 | 0.9 | 3.3 | 0.2 | 1.4 | 0.0 | 84.1 | 14.9 | 0.9 |
| I-15 | 1.6 | 0.6 | 1.5 | 0.2 | 1.1 | 0.0 | 98.5 | 1.5 | 0.0 |
| I-16 | 2.4 | 1.1 | 2.4 | 0.1 | 1.3 | 0.0 | 91.6 | 7.8 | 0.6 |
| I-12 | 3.2 | 0.8 | 3.2 | 0.2 | 1.4 | 0.0 | 87.2 | 11.9 | 0.8 |
| I-9 | 3.5 | 0.8 | 3.6 | 0.0 | 1.6 | 0.0 | 78.9 | 19.9 | 1.2 |
| I-2 | 1.6 | 0.6 | 1.5 | 0.3 | 1.0 | 0.0 | 99.8 | 0.2 | 0.0 |
| I-6 | 1.4 | 0.6 | 1.3 | 0.3 | 1.0 | 0.0 | 99.0 | 0.9 | 0.0 |
| I-3 | 1.3 | 0.8 | 1.1 | 0.6 | 1.7 | 0.0 | 99.5 | 0.4 | 0.0 |
| ***38 m stations*** | | | | | | | | | |
| I-29 | 3.7 | 1.0 | 3.8 | 0.2 | 2.0 | 0.0 | 67.2 | 31.0 | 1.7 |
| I-21 | 1.2 | 0.7 | 1.0 | 0.6 | 1.8 | 0.0 | 99.7 | 0.3 | 0.0 |
| I-13 | 1.3 | 0.6 | 1.2 | 0.1 | 1.2 | 0.8 | 99.1 | 0.1 | 0.0 |
| I-8 | 1.3 | 0.5 | 1.2 | 0.4 | 1.0 | 0.0 | 99.5 | 0.4 | 0.0 |
| ***55 m stations*** | | | | | | | | | |
| I-28 | 4.0 | 2.1 | 3.7 | 0.1 | 2.0 | 5.7 | 55.8 | 34.6 | 3.8 |
| I-20 | 0.9 | 0.6 | 1.0 | 0.0 | 3.3 | 4.0 | 95.8 | 0.1 | 0.0 |
| I-7 | 1.0 | 0.6 | 1.0 | 0.1 | 1.8 | 3.3 | 96.3 | 0.5 | 0.0 |
| I-1 | 2.7 | 0.9 | 2.7 | 0.3 | 2.0 | 0.0 | 90.3 | 8.8 | 0.9 |

## Appendix A.2

List of PAHs detected at two SBOO stations during July 2002.

| PAH COMPOUND | MDL | Station I-1 | Station I-35 |
|---|---|---|---|
| 3,4-BENZO(B)FLUORANTHENE | 27 | 20.3 | nd |
| BENZO[A]ANTHRACENE | 23 | 12.6 | 24.9 |
| BENZO[A]PYRENE | 18 | 0 | 19.5 |
| BENZO[E]PYRENE | 18 | 21.1 | 27.8 |
| BENZO[G,H,I]PERYLENE | 25 | 43.1 | nd |
| BENZO[K]FLUORANTHENE | 20 | 16.1 | 20.6 |
| DIBENZO(A,H)ANTHRACENE | 25 | 36.9 | nd |
| INDENO(1,2,3-CD)PYRENE | 22 | 35.7 | nd |

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# Appendix B

# Supporting Data

# 2002 SBOO Stations

# Demersal Fishes and Megabenthic Invertebrates

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## Appendix B.1

Summary of demersal fish species captured during 2002 at SBOO stations. Data are number of fish collected (N) and minimum, maximum and mean length (cm SL).

| Taxon/Species | Common Name | N | LENGTH Min | Max | Mean |
|---|---|---|---|---|---|
| SQUATINIFORMES | | | | | |
| Squatinidae | | | | | |
| *Squatina californica* | Pacific angel shark | 1 | 27 | 27 | 27 |
| RAJIFORMES | | | | | |
| Rajoidei | | | | | |
| *Platyrhinoidis triseriata* | thornback | 1 | 45 | 45 | 45 |
| Rajidae | | | | | |
| *Raja inornata* | California skate | 3 | 29 | 47 | 39 |
| CLUPEIFORMES | | | | | |
| Engraulidae | | | | | |
| *Engraulis mordax* | northern anchovy | 2 | 8 | 10 | 9 |
| Clupeidae | | | | | |
| *Sardinops sagax* | Pacific sardine | 1 | 14 | 14 | 14 |
| AULOPIFORMES | | | | | |
| Synodontidae | | | | | |
| *Synodus lucioceps* | California lizardfish | 43 | 10 | 29 | 17 |
| BATRACHOIDIFORMES | | | | | |
| Batrachoididae | | | | | |
| *Porichthys myriaster* | specklefin midshipman | 13 | 8 | 30 | 19 |
| *Porichthys notatus* | plainfin midshipman | 6 | 5 | 16 | 10 |
| GASTEROSTEIFORMES | | | | | |
| Syngnathidae | | | | | |
| *Syngnathus californiensis* | kelp pipefish | 1 | 25 | 25 | 25 |
| *Syngnathus exilis* | barcheek pipefish | 2 | 19 | 23 | 21 |
| SCORPAENIFORMES | | | | | |
| Scorpaenidae | | | | | |
| *Scorpaena guttata* | California scorpionfish | 26 | 15 | 31 | 22 |
| *Sebastes miniatus* | vermilion rockfish | 1 | 22 | 22 | 22 |
| Hexagrammidae | | | | | |
| *Zaniolepis latipinnis* | longspine combfish | 8 | 13 | 15 | 14 |
| Cottidae | | | | | |
| *Chitonotus pugetensis* | roughback sculpin | 36 | 7 | 11 | 9 |
| *Icelinus quadriseriatus* | yellowchin sculpin | 48 | 5 | 8 | 6 |
| Agonidae | | | | | |
| *Odontopyxis tripinosa* | pygmy poacher | 1 | 8 | 8 | 8 |
| *Xeneretmus triacanthus* | bluespotted poacher | 1 | 12 | 12 | 12 |

## Appendix B.1 continued

| Taxon/Species | Common Name | N | LENGTH Min | Max | Mean |
|---|---|---|---|---|---|
| PERCIFORMES | | | | | |
| Serranidae | | | | | |
| *Paralabrax nebulifer* | barred sand bass | 1 | 31 | 31 | 31 |
| Sciaenidae | | | | | |
| *Genyonemus lineatus* | white croaker | 84 | 9 | 24 | 17 |
| *Seriphus politus* | queenfish | 6 | 12 | 18 | 14 |
| Embiotocidae | | | | | |
| *Cymatogaster aggregata* | shiner perch | 11 | 8 | 10 | 9 |
| Stromateidae | | | | | |
| *Peprilus similimus* | Pacific pompano | 12 | 7 | 12 | 8 |
| PLEURONECTIFORMES | | 2 | 4 | 13 | 9 |
| Paralichthyidae | | | | | |
| *Citharichthys sordidus* | Pacific sanddab | 6 | 12 | 15 | 13 |
| *Citharichthys stigmaeus* | speckled sanddab | 2207 | 3 | 12 | 8 |
| *Citharichthys xanthostigma* | longfin sanddab | 128 | 8 | 20 | 14 |
| *Hippoglossina stomata* | bigmouth sole | 3 | 21 | 25 | 23 |
| *Paralichthys californicus* | California halibut | 29 | 18 | 49 | 33 |
| *Xystreurys liolepis* | fantail sole | 12 | 17 | 36 | 23 |
| Pleuronectidae | | | | | |
| *Hypsopsetta guttulata* | diamond turbot | 2 | 21 | 27 | 24 |
| *Pleuronectes vetulus* | English sole | 30 | 8 | 25 | 20 |
| *Pleuronichthys decurrens* | curlfin sole | 2 | 7 | 20 | 14 |
| *Pleuronichthys ritteri* | spotted turbot | 38 | 13 | 20 | 17 |
| *Pleuronichthys verticalis* | hornyhead turbot | 98 | 4 | 23 | 16 |
| Cynoglossidae | | | | | |
| *Symphurus atricauda* | California tonguefish | 42 | 7 | 18 | 13 |

Taxonomic arrangement from Nelson 1994.

## Appendix B.2

Summary of megabenthic invertebrate taxa captured during 2002 at SBOO stations. Data are number of individuals collected (N).

| Taxon/ Species | N |
|---|---|
| **PORIFERA** | 2 |
| | |
| **CNIDARIA** | |
| ANTHOZOA | |
| ALCYONACEA | |
| Muriceidae | |
| *Thesea* sp. B | 2 |
| PENNATULACEA | |
| Virgulariidae | |
| *Acanthoptilum* sp | 1 |
| | |
| **MOLLUSCA** | |
| GASTROPODA | |
| VETIGASTROPODA | |
| Trochidae | |
| *Calliostoma canaliculatum* | 3 |
| *Calliostoma gloriosum* | 1 |
| NEOTAENIOGLOSSA | |
| Naticidae | |
| *Euspira lewisii* | 5 |
| *Neverita reclusiana* | 1 |
| Bursidae | |
| *Crossata californica* | 1 |
| NEOGASTROPODA | |
| Muricidae | |
| *Pteropurpura vokesae* | 1 |
| Buccinidae | |
| *Kelletia kelletii* | 17 |
| Nassariidae | |
| *Nassarius perpinguis* | 1 |
| Mitridae | |
| *Mitra idea* | 1 |
| Turridae | |
| *Megastraea undosa* | 2 |
| CEPHALASPIDEA | |
| Philinidae | |
| *Philine auriformis* | 25 |
| Archiodorididae | |
| *Acrchidoris montereyensis* | 2 |
| NUDIBRANCHIA | |
| Onchidorididae | |
| *Acanthodoris brunnea* | 7 |
| Dendronotidae | |
| *Dendronotus frondosus* | 1 |
| BIVALVIA | |
| OSTREOIDA | |
| Pectinidae | |
| *Leptopecten latiauratus* | 1 |

## Appendix B.2 continued

| Taxon/ Species | N |
|---|---|
| CEPHALOPODA | |
| TEUTHOIDEA | |
| Loliginiidae | |
| *Loligo opalescens* | 20 |
| OCTOPODA | |
| Octopodidae | |
| *Octopus rubescens* | 1 |
| *Octopus* sp | 1 |
| | |
| **ANNELIDA** | |
| POLYCHATEA | |
| PHYLLODOCIDA | |
| Polynoidae | |
| *Arctonoe pulchra* | 3 |
| *Halosydna latior* | 1 |
| HIRUDINEA | 9 |
| | |
| **ARTHROPODA** | |
| MALACOSTRACA | |
| STOMATOPODA | |
| Hemisquillidae | |
| *Hemisquilla ensigera californiensis* | 7 |
| ISOPODA | |
| Cymothoidae | |
| *Elthusa vulgaris* | 5 |
| DECOPODA | |
| Hippolytidae | |
| *Heptacarpus palpator* | 41 |
| *Heptacarpus stimposoni* | 8 |
| *Heptacarpus taylori* | 2 |
| Crangonidae | |
| *Crangon alaskensis* | 5 |
| *Crangon alba* | 2 |
| *Crangon nigromaculata* | 131 |
| Diogenidae | |
| *Paguristes bakeri* | 2 |
| Paguridae | |
| *Pagurus spilocarpus* | 4 |
| Calappidae | |
| *Platymera gaudichaudii* | 2 |
| Leucosiidae | |
| *Randallia ornata* | 1 |
| Majidae | |
| *Loxorhynchus crispatus* | 2 |
| *Loxorhynchus grandis* | 7 |
| *Podochela hemphillii* | 2 |
| *Pyromaia tuberculata* | 26 |

## **Appendix B.2** continued

| Taxon/ Species | N |
| --- | --- |
| DECOPODA | |
| Parthenopidae | |
| *Heterocrypta occidentalis* | 31 |
| Cancridae | |
| *Cancer anthonyi* | 4 |
| *Cancer gracilis* | 1 |
| *Cancer jordani* | 1 |
| *Cancer* sp | 1 |
| **ECHINODERMATA** | |
| ASTEROIDEA | |
| PAXILLOSIDA | |
| Luidiidae | |
| *Luidia armata* | 4 |
| *Luidia foliolata* | 4 |
| Astropectinidae | |
| *Astropecten armatus* | 1 |
| *Astropecten verrilli* | 732 |
| *Astropecten* sp | 70 |
| FORCIPULATIDA | |
| Asteriidae | |
| *Pisaster brevispinus* | 20 |
| OPHIUROIDEA | |
| OPHIURIDA | |
| Ophiotricidae | |
| *Ophiothrix spiculata* | 3 |
| ECHINOIDEA | |
| TEMNOPLEUROIDA | |
| Toxopneustidae | |
| *Lytechinus pictus* | 255 |
| ECHINOIDA | |
| Strongylocentrotidae | |
| *Strongylocentrotus purpuratus* | 1 |
| CLYPEASTEROIDA | |
| Dendrasteridae | |
| *Dendraster terminalis* | 38 |

Taxonomic arrangement from SCAMIT 2002.

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# Appendix C

## Supporting Data

## 2002 SBOO Stations

## Bioaccumulation of Contaminants in Fish Tissue

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## Appendix C.1

Length and weights of fishes used in composite samples for April and October 2002.

| Station | Rep | Species | N | min lnth | max lnth | avg lnth | min wt | max wt | avg wt |
|---|---|---|---|---|---|---|---|---|---|
| ***April 2002*** | | | | | | | | | |
| SD15 | 1 | Hornyhead turbot | 4 | 18 | 21 | 20 | 149.0 | 254.0 | 209.8 |
| SD15 | 2 | Ca. scorpionfish | 3 | 24 | 25 | 25 | 423.0 | 551.0 | 504.7 |
| SD16 | 1 | Longfin sanddab | 11 | 17 | 21 | 19 | 54.0 | 111.0 | 79.1 |
| SD16 | 2 | Hornyhead turbot | 6 | 18 | 21 | 19 | 145.0 | 247.0 | 188.2 |
| SD16 | 3 | Ca. scorpionfish | 3 | 24 | 28 | 26 | 446.0 | 800.0 | 648.7 |
| SD17 | 1 | Longfin sanddab | 12 | 13 | 17 | 15 | 65.0 | 98.0 | 77.4 |
| SD17 | 2 | Hornyhead turbot | 5 | 16 | 21 | 19 | 125.0 | 255.0 | 203.4 |
| SD17 | 3 | Ca. scorpionfish | 3 | 17 | 24 | 21 | 122.0 | 436.0 | 303.3 |
| SD18 | 1 | Longfin sanddab | 10 | 14 | 18 | 16 | 57.4 | 141.3 | 88.2 |
| SD18 | 2 | Longfin sanddab | 9 | 15 | 19 | 17 | 70.9 | 127.5 | 100.9 |
| SD18 | 3 | Hornyhead turbot | 4 | 19 | 24 | 21 | 183.5 | 332.9 | 247.7 |
| SD19 | 1 | Longfin sanddab | 4 | 18 | 19 | 19 | 133.3 | 171.9 | 150.9 |
| SD19 | 2 | Longfin sanddab | 7 | 16 | 19 | 18 | 96.1 | 146.8 | 121.9 |
| SD19 | 3 | Hornyhead turbot | 3 | 22 | 23 | 23 | 273.8 | 305.8 | 294.7 |
| SD20 | 1 | Longfin sanddab | 6 | 16 | 19 | 17 | 83.3 | 151.1 | 100.0 |
| SD20 | 2 | English sole | 4 | 21 | 27 | 24 | 118.9 | 276.0 | 209.3 |
| SD20 | 3 | Ca. scorpionfish | 3 | 26 | 30 | 28 | 611.0 | 950.0 | 737.0 |
| SD21 | 1 | Longfin sanddab | 10 | 13 | 17 | 15 | 46.4 | 108.6 | 70.3 |
| SD21 | 2 | Hornyhead turbot | 3 | 21 | 21 | 21 | 280.6 | 287.3 | 283.8 |
| SD21 | 3 | Hornyhead turbot | 6 | 17 | 28 | 21 | 123.4 | 265.5 | 169.7 |
| RF3 | 1 | Barred sand bass | 3 | 31 | 40 | 35 | 602.1 | 1400.0 | 934.0 |
| RF3 | 2 | Ca. scorpionfish | 3 | 29 | 30 | 29 | 850.0 | 1000.0 | 916.7 |
| RF3 | 3 | Vermilion rockfish | 3 | 25 | 26 | 25 | 388.8 | 486.3 | 436.5 |
| RF4 | 1 | Ca. scorpionfish | 3 | 24 | 30 | 26 | 406.0 | 1000.0 | 609.8 |
| RF4 | 2 | Ca. scorpionfish | 3 | 23 | 34 | 29 | 474.3 | 1600.0 | 1058.1 |
| RF4 | 3 | Ca. scorpionfish | 3 | 23 | 26 | 24 | 397.4 | 561.6 | 489.1 |
| ***October 2002*** | | | | | | | | | |
| SD15 | 1 | Ca. scorpionfish | 3 | 17 | 25 | 21 | 143.9 | 576.8 | 331.2 |
| SD15 | 2 | Ca. scorpionfish | 3 | 15 | 25 | 19 | 117.4 | 482.9 | 250.5 |
| SD15 | 3 | Ca. scorpionfish | 3 | 18 | 19 | 18 | 186.2 | 290.4 | 240.8 |
| SD16 | 1 | Ca. scorpionfish | 3 | 22 | 23 | 23 | 315.2 | 435.0 | 384.8 |
| SD16 | 2 | Ca. scorpionfish | 3 | 21 | 22 | 21 | 274.5 | 371.9 | 329.9 |
| SD16 | 3 | Ca. scorpionfish | 3 | 22 | 28 | 24 | 388.2 | 760.0 | 530.3 |
| SD17 | 1 | Ca. scorpionfish | 3 | 20 | 22 | 21 | 207.6 | 353.3 | 290.6 |
| SD17 | 2 | Ca. scorpionfish | 3 | 20 | 26 | 22 | 234.3 | 551.6 | 360.8 |
| SD17 | 3 | Ca. scorpionfish | 3 | 18 | 22 | 21 | 241.2 | 387.7 | 319.2 |
| SD18 | 1 | Hornyhead turbot | 5 | 18 | 21 | 20 | 137.0 | 258.0 | 192.6 |
| SD18 | 2 | Hornyhead turbot | 7 | 17 | 19 | 17 | 126.0 | 190.0 | 148.0 |
| SD19 | 1 | Hornyhead turbot | 7 | 13 | 18 | 15 | 69.9 | 181.6 | 111.0 |
| SD19 | 2 | Ca. scorpionfish | 3 | 17 | 22 | 19 | 182.6 | 351.0 | 247.7 |
| SD20 | 1 | Hornyhead turbot | 6 | 15 | 20 | 17 | 89.1 | 226.2 | 146.0 |
| SD20 | 2 | Longfin sanddab | 3 | 16 | 17 | 16 | 92.2 | 98.8 | 95.5 |
| SD20 | 3 | Ca. scorpionfish | 3 | 22 | 25 | 23 | 292.1 | 448.2 | 385.5 |
| SD21 | 1 | Ca. scorpionfish | 3 | 16 | 25 | 21 | 139.4 | 512.7 | 333.0 |
| SD21 | 2 | Longfin sanddab | 9 | 13 | 18 | 15 | 45.9 | 121.2 | 69.8 |
| SD21 | 3 | Ca. scorpionfish | 3 | 22 | 26 | 24 | 35.7 | 610.3 | 320.5 |
| RF3 | 1 | Vermilion rockfish | 3 | 23 | 28 | 25 | 407.0 | 600.0 | 480.0 |
| RF3 | 2 | Brown rockfish | 3 | 21 | 28 | 24 | 258.6 | 562.8 | 388.8 |
| RF3 | 3 | Vermilion rockfish | 3 | 26 | 28 | 27 | 562.0 | 700.0 | 620.7 |
| RF4 | 1 | Ca. scorpionfish | 3 | 24 | 28 | 26 | 374.2 | 800.0 | 589.4 |
| RF4 | 2 | Ca. scorpionfish | 3 | 23 | 27 | 25 | 415.0 | 600.0 | 515.7 |
| RF4 | 3 | Ca. scorpionfish | 3 | 24 | 27 | 26 | 442.3 | 700.0 | 614.1 |

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## Appendix C.2

Analyzed constituents for fish tissue samples for April and October 2002.

**Chlorinated Pesticides**

| | | | |
|---|---|---|---|
| Aldrin | BHC, Delta isomer | Heptachlor epoxide | p,p-DDD |
| Alpha (cis) Chlordane | BHC, Gamma isomer | Hexachlorobenzene | p,p-DDE |
| Gamma (trans) Chlordane | Cis Nonachlor | Mirex | p,p-DDT |
| Alpha Endosulfan | Dieldrin | o,p-DDD | Oxychlordane |
| BHC, Alpha isomer | Endrin | o,p-DDE | Trans Nonachlor |
| BHC, Beta isomer | Heptachlor | o,p-DDT | Toxaphene |

**Polycyclic Aromatic Hydrocarbons**

| | | | |
|---|---|---|---|
| 1-methylnaphthalene | Acenaphthene | Benzo(e)pyrene | Fluorene |
| 1-methylphenanthrene | Acenaphthylene | Benzo(G,H,I)perylene | Indeno(1,2,3-CD)pyrene |
| 2,3,5-trimethylnaphthalene | Anthracene | Benzo(K)fluoranthene | Naphthalene |
| 2,6-dimethylnaphthalene | Benzo(A)anthracene | Biphenyl | Perylene |
| 2-methylnaphthalene | Dibenzo(A,H)anthracene | Chrysene | Phenanthrene |
| 3,4-benzo(B)fluoranthene | Benzo(A)pyrene | Fluoranthene | Pyrene |

**Metals**

| | | | |
|---|---|---|---|
| Aluminum | Chromium | Manganese | Silver |
| Antimony | Copper | Mercury | Thallium |
| Arsenic | Iron | Nickel | Tin |
| Beryllium | Lead | Selenium | Zinc |
| Cadmium | | | |

**PCB Congeners**

| | | | |
|---|---|---|---|
| PCB 18 | PCB 81 | PCB 126 | PCB 169 |
| PCB 28 | PCB 87 | PCB 128 | PCB 170 |
| PCB 37 | PCB 99 | PCB 138 | PCB 177 |
| PCB 44 | PCB 101 | PCB 149 | PCB 180 |
| PCB 49 | PCB 105 | PCB 151 | PCB 183 |
| PCB 52 | PCB 110 | PCB 153/168 | PCB 187 |
| PCB 66 | PCB 114 | PCB 156 | PCB 189 |
| PCB 70 | PCB 118 | PCB 157 | PCB 194 |
| PCB 74 | PCB 119 | PCB 158 | PCB 201 |
| PCB 77 | PCB 123 | PCB 167 | PCB 206 |

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# Appendix C.3

April 2002

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| RF3 | 1 | Barred sand bass | Muscle | Aluminum | 11.8 | | mg/kg | 2.6 |
| RF3 | 1 | Barred sand bass | Muscle | Lipids | 0.33 | | wt% | 0.005 |
| RF3 | 1 | Barred sand bass | Muscle | Mercury | 0.486 | | mg/kg | 0.03 |
| RF3 | 1 | Barred sand bass | Muscle | p,p-DDE | 6.8 | | ug/kg | 1.33 |
| RF3 | 1 | Barred sand bass | Muscle | PCB 101 | 0.5 | E | ug/kg | |
| RF3 | 1 | Barred sand bass | Muscle | PCB 118 | 0.4 | E | ug/kg | |
| RF3 | 1 | Barred sand bass | Muscle | PCB 128 | 0.2 | E | ug/kg | |
| RF3 | 1 | Barred sand bass | Muscle | PCB 138 | 0.9 | E | ug/kg | |
| RF3 | 1 | Barred sand bass | Muscle | PCB 149 | 0.2 | E | ug/kg | |
| RF3 | 1 | Barred sand bass | Muscle | PCB 153/168 | 1.5 | | ug/kg | 1.33 |
| RF3 | 1 | Barred sand bass | Muscle | PCB 180 | 0.5 | E | ug/kg | |
| RF3 | 1 | Barred sand bass | Muscle | PCB 183 | 0.2 | E | ug/kg | |
| RF3 | 1 | Barred sand bass | Muscle | PCB 187 | 0.6 | E | ug/kg | |
| RF3 | 1 | Barred sand bass | Muscle | PCB 206 | 0.2 | E | ug/kg | |
| RF3 | 1 | Barred sand bass | Muscle | PCB 99 | 0.5 | E | ug/kg | |
| RF3 | 1 | Barred sand bass | Muscle | Total Solids | 22.6 | | wt% | 0.4 |
| RF3 | 1 | Barred sand bass | Muscle | Zinc | 4.2 | | mg/kg | 0.58 |
| RF3 | 2 | Ca. scorpionfish | Muscle | Aluminum | 3.3 | | mg/kg | 2.6 |
| RF3 | 2 | Ca. scorpionfish | Muscle | Arsenic | 1.9 | | mg/kg | 1.4 |
| RF3 | 2 | Ca. scorpionfish | Muscle | Iron | 2.5 | | mg/kg | 1.3 |
| RF3 | 2 | Ca. scorpionfish | Muscle | Lipids | 0.94 | | wt% | 0.005 |
| RF3 | 2 | Ca. scorpionfish | Muscle | Mercury | 0.198 | | mg/kg | 0.03 |
| RF3 | 2 | Ca. scorpionfish | Muscle | p,p-DDE | 5.1 | | ug/kg | 1.33 |
| RF3 | 2 | Ca. scorpionfish | Muscle | PCB 118 | 0.2 | E | ug/kg | |
| RF3 | 2 | Ca. scorpionfish | Muscle | PCB 138 | 0.3 | E | ug/kg | |
| RF3 | 2 | Ca. scorpionfish | Muscle | PCB 153/168 | 0.5 | E | ug/kg | |
| RF3 | 2 | Ca. scorpionfish | Muscle | PCB 180 | 0.2 | E | ug/kg | |
| RF3 | 2 | Ca. scorpionfish | Muscle | PCB 187 | 0.1 | E | ug/kg | |
| RF3 | 2 | Ca. scorpionfish | Muscle | PCB 206 | 0.2 | E | ug/kg | |
| RF3 | 2 | Ca. scorpionfish | Muscle | Selenium | 0.15 | | mg/kg | 0.13 |
| RF3 | 2 | Ca. scorpionfish | Muscle | Total Solids | 21.8 | | wt% | 0.4 |
| RF3 | 2 | Ca. scorpionfish | Muscle | Zinc | 3.61 | | mg/kg | 0.58 |
| RF3 | 3 | Vermilion rockfish | Muscle | Arsenic | 2.1 | | mg/kg | 1.4 |
| RF3 | 3 | Vermilion rockfish | Muscle | Iron | 1.7 | | mg/kg | 1.3 |
| RF3 | 3 | Vermilion rockfish | Muscle | Lipids | 0.27 | | wt% | 0.005 |
| RF3 | 3 | Vermilion rockfish | Muscle | p,p-DDE | 1.3 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 206 | 0.1 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | Total Solids | 20.3 | | wt% | 0.4 |
| RF3 | 3 | Vermilion rockfish | Muscle | Zinc | 2.74 | | mg/kg | 0.58 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Aluminum | 8.9 | | mg/kg | 2.6 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Iron | 7 | | mg/kg | 1.3 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Lipids | 0.3 | | wt% | 0.005 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Mercury | 0.262 | | mg/kg | 0.03 |
| RF4 | 1 | Ca. scorpionfish | Muscle | p,p-DDD | 0.5 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | p,p-DDE | 16 | | ug/kg | 1.33 |
| RF4 | 1 | Ca. scorpionfish | Muscle | p,p-DDT | 0.4 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 101 | 0.5 | E | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 110 | 0.2 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 118 | 0.6 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 138 | 0.7 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 149 | 0.3 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 153/168 | 1.5 | | ug/kg | 1.33 |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 180 | 0.4 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 187 | 0.4 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 206 | 0.2 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 99 | 0.4 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | Selenium | 0.18 | | mg/kg | 0.13 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Total Solids | 22.8 | | wt% | 0.4 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Zinc | 5.33 | | mg/kg | 0.58 |
| RF4 | 2 | Ca. scorpionfish | Muscle | Hexachlorobenzene | 0.2 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | Iron | 7.2 | | mg/kg | 1.3 |
| RF4 | 2 | Ca. scorpionfish | Muscle | Lipids | 4.9 | | wt% | 0.005 |
| RF4 | 2 | Ca. scorpionfish | Muscle | Mercury | 0.217 | | mg/kg | 0.03 |
| RF4 | 2 | Ca. scorpionfish | Muscle | p,p-DDD | 1.6 | | ug/kg | 1.33 |
| RF4 | 2 | Ca. scorpionfish | Muscle | p,p-DDE | 51 | | ug/kg | 1.33 |
| RF4 | 2 | Ca. scorpionfish | Muscle | p,p-DDT | 1.6 | | ug/kg | 1.33 |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 101 | 1 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 105 | 0.4 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 110 | 0.7 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 118 | 2 | | ug/kg | 1.33 |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 123 | 0.2 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 138 | 1.8 | | ug/kg | 1.33 |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 149 | 0.5 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 151 | 0.5 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 153/168 | 4.1 | | ug/kg | 1.33 |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 167 | 0.1 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 177 | 0.3 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 180 | 1 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 183 | 0.4 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 187 | 1.2 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 194 | 0.3 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 206 | 0.3 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 66 | 0.3 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 74 | 0.2 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 87 | 0.3 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 99 | 1.3 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | Selenium | 0.25 | | mg/kg | 0.13 |
| RF4 | 2 | Ca. scorpionfish | Muscle | Total Solids | 22.9 | | wt% | 0.4 |
| RF4 | 2 | Ca. scorpionfish | Muscle | Trans Nonachlor | 1 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | Zinc | 5.05 | | mg/kg | 0.58 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Aluminum | 9.2 | | mg/kg | 2.6 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Copper | 0.92 | | mg/kg | 0.76 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Iron | 4.7 | | mg/kg | 1.3 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Lipids | 0.84 | | wt% | 0.005 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Mercury | 0.138 | | mg/kg | 0.03 |
| RF4 | 3 | Ca. scorpionfish | Muscle | p,p-DDD | 0.7 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | p,p-DDE | 32 | | ug/kg | 1.33 |
| RF4 | 3 | Ca. scorpionfish | Muscle | p,p-DDT | 0.4 | E | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 101 | 0.7 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 105 | 0.4 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 110 | 0.4 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 118 | 1.7 | | ug/kg | 1.33 |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 128 | 0.4 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 138 | 1.7 | | ug/kg | 1.33 |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 149 | 0.3 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 177 | 0.1 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 180 | 0.7 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 183 | 0.3 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 187 | 0.9 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 194 | 0.3 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 206 | 0.2 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 66 | 0.3 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 74 | 0.2 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 87 | 0.2 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 99 | 1 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | Selenium | 0.29 | | mg/kg | 0.17 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Total Solids | 22 | | wt% | 0.4 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Zinc | 4 | | mg/kg | 0.58 |
| SD15 | 1 | Hornyhead turbot | Liver | Aluminum | 3.8 | | mg/kg | 2.6 |
| SD15 | 1 | Hornyhead turbot | Liver | Arsenic | 3.4 | | mg/kg | 1.4 |
| SD15 | 1 | Hornyhead turbot | Liver | Cadmium | 8.64 | | mg/kg | 0.34 |
| SD15 | 1 | Hornyhead turbot | Liver | Hexachlorobenzene | 0.7 | E | ug/kg | |
| SD15 | 1 | Hornyhead turbot | Liver | Iron | 61.3 | | mg/kg | 1.3 |
| SD15 | 1 | Hornyhead turbot | Liver | Lipids | 5.87 | | wt% | 0.005 |
| SD15 | 1 | Hornyhead turbot | Liver | Manganese | 1.73 | | mg/kg | 0.23 |
| SD15 | 1 | Hornyhead turbot | Liver | Mercury | 0.043 | | mg/kg | 0.012 |
| SD15 | 1 | Hornyhead turbot | Liver | p,p-DDE | 58 | | ug/kg | 13.3 |
| SD15 | 1 | Hornyhead turbot | Liver | PCB 101 | 1.4 | E | ug/kg | |
| SD15 | 1 | Hornyhead turbot | Liver | PCB 138 | 1.8 | E | ug/kg | |
| SD15 | 1 | Hornyhead turbot | Liver | PCB 153/168 | 4.9 | E | ug/kg | |
| SD15 | 1 | Hornyhead turbot | Liver | PCB 180 | 2.4 | E | ug/kg | |
| SD15 | 1 | Hornyhead turbot | Liver | PCB 206 | 1.9 | E | ug/kg | |
| SD15 | 1 | Hornyhead turbot | Liver | Selenium | 0.49 | | mg/kg | 0.17 |
| SD15 | 1 | Hornyhead turbot | Liver | Total Solids | 25.6 | | wt% | 0.4 |
| SD15 | 1 | Hornyhead turbot | Liver | Zinc | 39.8 | | mg/kg | 0.58 |
| SD15 | 2 | Ca. scorpionfish | Liver | Arsenic | 5.6 | | mg/kg | 1.4 |
| SD15 | 2 | Ca. scorpionfish | Liver | Cadmium | 0.425 | | mg/kg | 0.34 |
| SD15 | 2 | Ca. scorpionfish | Liver | Copper | 32.8 | | mg/kg | 0.76 |
| SD15 | 2 | Ca. scorpionfish | Liver | Hexachlorobenzene | 1 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | Iron | 63.3 | | mg/kg | 1.3 |
| SD15 | 2 | Ca. scorpionfish | Liver | Lipids | 20.5 | | wt% | 0.005 |
| SD15 | 2 | Ca. scorpionfish | Liver | Manganese | 0.49 | | mg/kg | 0.23 |
| SD15 | 2 | Ca. scorpionfish | Liver | Mercury | 0.0695 | | mg/kg | 0.012 |
| SD15 | 2 | Ca. scorpionfish | Liver | p,p-DDD | 5.8 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | p,p-DDE | 260 | | ug/kg | 13.3 |
| SD15 | 2 | Ca. scorpionfish | Liver | p,p-DDT | 4.1 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 101 | 6.7 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 105 | 2.7 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 110 | 3.3 | E | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 118 | 9.9 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 128 | 3.3 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 138 | 14 | | ug/kg | 13.3 |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 149 | 3 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 151 | 3.1 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 153/168 | 24 | | ug/kg | 13.3 |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 158 | 1 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 177 | 2.7 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 180 | 12 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 183 | 3.4 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 187 | 9.5 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 194 | 2.3 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 206 | 2.2 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 74 | 1.1 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 99 | 6.3 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | Selenium | 0.82 | | mg/kg | 0.13 |
| SD15 | 2 | Ca. scorpionfish | Liver | Total Solids | 46.1 | | wt% | 0.4 |
| SD15 | 2 | Ca. scorpionfish | Liver | Zinc | 95.3 | | mg/kg | 0.58 |
| SD16 | 1 | Longfin sanddab | Liver | Alpha (cis) Chlordane | 11 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | Cadmium | 1.57 | | mg/kg | 0.34 |
| SD16 | 1 | Longfin sanddab | Liver | Chromium | 5.06 | | mg/kg | 0.3 |
| SD16 | 1 | Longfin sanddab | Liver | Copper | 7.3 | | mg/kg | 0.76 |
| SD16 | 1 | Longfin sanddab | Liver | Hexachlorobenzene | 2.4 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | Iron | 171 | | mg/kg | 1.3 |
| SD16 | 1 | Longfin sanddab | Liver | Lipids | 4.69 | | wt% | 0.005 |
| SD16 | 1 | Longfin sanddab | Liver | Manganese | 2.19 | | mg/kg | 0.23 |
| SD16 | 1 | Longfin sanddab | Liver | Mercury | 0.17 | | mg/kg | 0.012 |
| SD16 | 1 | Longfin sanddab | Liver | Nickel | 1.55 | | mg/kg | 0.79 |
| SD16 | 1 | Longfin sanddab | Liver | o,p-DDE | 14 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | p,p-DDD | 13 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | p,p-DDE | 1280 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | p,p-DDT | 24 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | PCB 101 | 13 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 105 | 18 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | PCB 110 | 9.7 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 118 | 62 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | PCB 123 | 5.4 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 128 | 17 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | PCB 138 | 96 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | PCB 149 | 9.1 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 151 | 12 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 153/168 | 150 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | PCB 156 | 8.8 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 157 | 2.3 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 158 | 5.9 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 167 | 3.3 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 170 | 29 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | PCB 177 | 11 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 180 | 64 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | PCB 183 | 18 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | PCB 187 | 58 | | ug/kg | 13.3 |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD16 | 1 | Longfin sanddab | Liver | PCB 194 | 15 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | PCB 201 | 15 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | PCB 206 | 7.3 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 52 | 4.9 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 66 | 4.6 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 74 | 5.3 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 87 | 2 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | PCB 99 | 40 | | ug/kg | 13.3 |
| SD16 | 1 | Longfin sanddab | Liver | Selenium | 0.88 | | mg/kg | 0.13 |
| SD16 | 1 | Longfin sanddab | Liver | Total Solids | 43.1 | | wt% | 0.4 |
| SD16 | 1 | Longfin sanddab | Liver | Trans Nonachlor | 14 | E | ug/kg | |
| SD16 | 1 | Longfin sanddab | Liver | Zinc | 26 | | mg/kg | 0.58 |
| SD16 | 2 | Hornyhead turbot | Liver | Aluminum | 3.4 | | mg/kg | 2.6 |
| SD16 | 2 | Hornyhead turbot | Liver | Arsenic | 8.3 | | mg/kg | 1.4 |
| SD16 | 2 | Hornyhead turbot | Liver | Cadmium | 6.9 | | mg/kg | 0.34 |
| SD16 | 2 | Hornyhead turbot | Liver | Copper | 2.06 | | mg/kg | 0.76 |
| SD16 | 2 | Hornyhead turbot | Liver | Iron | 38 | | mg/kg | 1.3 |
| SD16 | 2 | Hornyhead turbot | Liver | Lipids | 25.8 | | wt% | 0.005 |
| SD16 | 2 | Hornyhead turbot | Liver | Manganese | 1.72 | | mg/kg | 0.23 |
| SD16 | 2 | Hornyhead turbot | Liver | Mercury | 0.127 | | mg/kg | 0.012 |
| SD16 | 2 | Hornyhead turbot | Liver | p,p-DDD | 2.2 | E | ug/kg | |
| SD16 | 2 | Hornyhead turbot | Liver | p,p-DDE | 78 | | ug/kg | 13.3 |
| SD16 | 2 | Hornyhead turbot | Liver | PCB 118 | 1.9 | E | ug/kg | |
| SD16 | 2 | Hornyhead turbot | Liver | PCB 138 | 3.2 | E | ug/kg | |
| SD16 | 2 | Hornyhead turbot | Liver | PCB 153/168 | 6.1 | E | ug/kg | |
| SD16 | 2 | Hornyhead turbot | Liver | PCB 180 | 3.4 | E | ug/kg | |
| SD16 | 2 | Hornyhead turbot | Liver | PCB 187 | 2.5 | E | ug/kg | |
| SD16 | 2 | Hornyhead turbot | Liver | PCB 206 | 2.1 | E | ug/kg | |
| SD16 | 2 | Hornyhead turbot | Liver | PCB 99 | 2 | E | ug/kg | |
| SD16 | 2 | Hornyhead turbot | Liver | Selenium | 0.705 | | mg/kg | 0.17 |
| SD16 | 2 | Hornyhead turbot | Liver | Total Solids | 23 | | wt% | 0.4 |
| SD16 | 2 | Hornyhead turbot | Liver | Zinc | 30.6 | | mg/kg | 0.58 |
| SD16 | 3 | Ca. scorpionfish | Liver | Cadmium | 4.52 | | mg/kg | 0.34 |
| SD16 | 3 | Ca. scorpionfish | Liver | Copper | 12.1 | | mg/kg | 0.76 |
| SD16 | 3 | Ca. scorpionfish | Liver | Hexachlorobenzene | 1.45 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | Iron | 202 | | mg/kg | 1.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | Lipids | 21.4 | | wt% | 0.005 |
| SD16 | 3 | Ca. scorpionfish | Liver | Manganese | 0.37 | | mg/kg | 0.23 |
| SD16 | 3 | Ca. scorpionfish | Liver | Mercury | 0.275 | | mg/kg | 0.012 |
| SD16 | 3 | Ca. scorpionfish | Liver | o,p-DDE | 4.3 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | p,p-DDD | 18.5 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | p,p-DDE | 825 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | p,p-DDT | 11.5 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 101 | 16.5 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 105 | 7.6 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 110 | 9.1 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 118 | 28.5 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 123 | 3.35 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 128 | 8.2 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 138 | 39 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 149 | 10.2 | | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 151 | 7.05 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 153/168 | 67 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 156 | 4.95 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 158 | 2.8 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 167 | 2.5 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 177 | 6.85 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 180 | 33 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 183 | 8 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 187 | 27.5 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 194 | 5.65 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 206 | 4 | E | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 66 | 4.9 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 74 | 3 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 87 | 4 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 99 | 14.5 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | Selenium | 0.81 | | mg/kg | 0.13 |
| SD16 | 3 | Ca. scorpionfish | Liver | Total Solids | 44.2 | | wt% | 0.4 |
| SD16 | 3 | Ca. scorpionfish | Liver | Trans Nonachlor | 12.5 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | Zinc | 118 | | mg/kg | 0.58 |
| SD17 | 1 | Longfin sanddab | Liver | Aluminum | 2.7 | | mg/kg | 2.6 |
| SD17 | 1 | Longfin sanddab | Liver | Arsenic | 7.5 | | mg/kg | 1.4 |
| SD17 | 1 | Longfin sanddab | Liver | Cadmium | 1.31 | | mg/kg | 0.34 |
| SD17 | 1 | Longfin sanddab | Liver | Copper | 3.74 | | mg/kg | 0.76 |
| SD17 | 1 | Longfin sanddab | Liver | Hexachlorobenzene | 2.4 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | Iron | 151 | | mg/kg | 1.3 |
| SD17 | 1 | Longfin sanddab | Liver | Lipids | 22 | | wt% | 0.005 |
| SD17 | 1 | Longfin sanddab | Liver | Manganese | 1.12 | | mg/kg | 0.23 |
| SD17 | 1 | Longfin sanddab | Liver | Mercury | 0.153 | | mg/kg | 0.012 |
| SD17 | 1 | Longfin sanddab | Liver | o,p-DDE | 17 | | ug/kg | 13.3 |
| SD17 | 1 | Longfin sanddab | Liver | o,p-DDT | 2.1 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | p,p-DDD | 13 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | p,p-DDE | 970 | | ug/kg | 13.3 |
| SD17 | 1 | Longfin sanddab | Liver | p,p-DDT | 19 | | ug/kg | 13.3 |
| SD17 | 1 | Longfin sanddab | Liver | PCB 101 | 9.6 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 105 | 9.6 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 110 | 5.9 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 118 | 34 | | ug/kg | 13.3 |
| SD17 | 1 | Longfin sanddab | Liver | PCB 123 | 3.7 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 128 | 10 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 138 | 63 | | ug/kg | 13.3 |
| SD17 | 1 | Longfin sanddab | Liver | PCB 149 | 8.8 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 151 | 9.3 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 153/168 | 110 | | ug/kg | 13.3 |
| SD17 | 1 | Longfin sanddab | Liver | PCB 156 | 5.7 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 157 | 2.1 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 158 | 3.7 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 167 | 4.1 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 170 | 23 | | ug/kg | 13.3 |
| SD17 | 1 | Longfin sanddab | Liver | PCB 177 | 9.2 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 180 | 47 | | ug/kg | 13.3 |
| SD17 | 1 | Longfin sanddab | Liver | PCB 183 | 18 | | ug/kg | 13.3 |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD17 | 1 | Longfin sanddab | Liver | PCB 187 | 48 | | ug/kg | 13.3 |
| SD17 | 1 | Longfin sanddab | Liver | PCB 194 | 12 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 201 | 15 | | ug/kg | 13.3 |
| SD17 | 1 | Longfin sanddab | Liver | PCB 206 | 6.7 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 66 | 3.7 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 74 | 2.8 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | PCB 99 | 23 | | ug/kg | 13.3 |
| SD17 | 1 | Longfin sanddab | Liver | Selenium | 1.23 | | mg/kg | 0.13 |
| SD17 | 1 | Longfin sanddab | Liver | Total Solids | 41 | | wt% | 0.4 |
| SD17 | 1 | Longfin sanddab | Liver | Trans Nonachlor | 12 | E | ug/kg | |
| SD17 | 1 | Longfin sanddab | Liver | Zinc | 22.8 | | mg/kg | 0.58 |
| SD17 | 2 | Hornyhead turbot | Liver | Arsenic | 2.7 | | mg/kg | 1.4 |
| SD17 | 2 | Hornyhead turbot | Liver | Cadmium | 6.98 | | mg/kg | 0.34 |
| SD17 | 2 | Hornyhead turbot | Liver | Copper | 3.7 | | mg/kg | 0.76 |
| SD17 | 2 | Hornyhead turbot | Liver | Iron | 51.3 | | mg/kg | 1.3 |
| SD17 | 2 | Hornyhead turbot | Liver | Lipids | 3.63 | | wt% | 0.005 |
| SD17 | 2 | Hornyhead turbot | Liver | Manganese | 1.66 | | mg/kg | 0.23 |
| SD17 | 2 | Hornyhead turbot | Liver | Mercury | 0.11 | | mg/kg | 0.012 |
| SD17 | 2 | Hornyhead turbot | Liver | p,p-DDD | 1.6 | E | ug/kg | |
| SD17 | 2 | Hornyhead turbot | Liver | p,p-DDE | 67 | | ug/kg | 13.3 |
| SD17 | 2 | Hornyhead turbot | Liver | PCB 118 | 2.5 | E | ug/kg | |
| SD17 | 2 | Hornyhead turbot | Liver | PCB 138 | 2.6 | E | ug/kg | |
| SD17 | 2 | Hornyhead turbot | Liver | PCB 153/168 | 4.3 | E | ug/kg | |
| SD17 | 2 | Hornyhead turbot | Liver | PCB 180 | 2.7 | E | ug/kg | |
| SD17 | 2 | Hornyhead turbot | Liver | PCB 187 | 1.7 | E | ug/kg | |
| SD17 | 2 | Hornyhead turbot | Liver | PCB 206 | 1.7 | E | ug/kg | |
| SD17 | 2 | Hornyhead turbot | Liver | Selenium | 0.56 | | mg/kg | 0.13 |
| SD17 | 2 | Hornyhead turbot | Liver | Total Solids | 23.2 | | wt% | 0.4 |
| SD17 | 2 | Hornyhead turbot | Liver | Zinc | 35.4 | | mg/kg | 0.58 |
| SD17 | 3 | Ca. scorpionfish | Liver | Aluminum | 4.5 | | mg/kg | 2.6 |
| SD17 | 3 | Ca. scorpionfish | Liver | Arsenic | 5.8 | | mg/kg | 1.4 |
| SD17 | 3 | Ca. scorpionfish | Liver | Cadmium | 1.22 | | mg/kg | 0.34 |
| SD17 | 3 | Ca. scorpionfish | Liver | Copper | 19.6 | | mg/kg | 0.76 |
| SD17 | 3 | Ca. scorpionfish | Liver | Hexachlorobenzene | 1.2 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | Iron | 216 | | mg/kg | 1.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | Lipids | 15.9 | | wt% | 0.005 |
| SD17 | 3 | Ca. scorpionfish | Liver | Manganese | 0.55 | | mg/kg | 0.23 |
| SD17 | 3 | Ca. scorpionfish | Liver | Mercury | 0.181 | | mg/kg | 0.012 |
| SD17 | 3 | Ca. scorpionfish | Liver | p,p-DDD | 5 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | p,p-DDE | 300 | | ug/kg | 13.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | p,p-DDT | 3.4 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 101 | 11 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 105 | 7.8 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 110 | 6.4 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 114 | 4.9 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 118 | 22 | | ug/kg | 13.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 119 | 2.7 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 123 | 5.9 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 126 | 5.2 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 128 | 11 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 138 | 41 | | ug/kg | 13.3 |

| Station | Rep | Species | Tissue | Parameter | Value | Units | MDL |
|---|---|---|---|---|---|---|---|
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 149 | 6.4 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 151 | 7.5 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 153/168 | 72 | ug/kg | 13.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 156 | 9.5 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 157 | 5.9 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 158 | 5.5 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 167 | 5.8 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 170 | 19 | ug/kg | 13.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 177 | 9.5 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 180 | 41 | ug/kg | 13.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 183 | 13 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 187 | 33 | ug/kg | 13.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 189 | 4.8 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 194 | 11 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 201 | 15 | ug/kg | 13.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 206 | 8.7 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 66 | 4.6 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 70 | 3.9 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 74 | 4 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 81 | 4.1 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 87 | 4.7 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 99 | 13 E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | Selenium | 1.04 | mg/kg | 0.13 |
| SD17 | 3 | Ca. scorpionfish | Liver | Silver | 0.7 | mg/kg | 0.62 |
| SD17 | 3 | Ca. scorpionfish | Liver | Total Solids | 40.6 | wt% | 0.4 |
| SD17 | 3 | Ca. scorpionfish | Liver | Zinc | 108 | mg/kg | 0.58 |
| SD18 | 1 | Longfin sanddab | Liver | Alpha (cis) Chlordane | 5.1 E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | Aluminum | 2.6 | mg/kg | 2.6 |
| SD18 | 1 | Longfin sanddab | Liver | Arsenic | 11.8 | mg/kg | 1.4 |
| SD18 | 1 | Longfin sanddab | Liver | Cadmium | 1.8 | mg/kg | 0.34 |
| SD18 | 1 | Longfin sanddab | Liver | Copper | 3.43 | mg/kg | 0.76 |
| SD18 | 1 | Longfin sanddab | Liver | Hexachlorobenzene | 1.7 E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | Iron | 129 | mg/kg | 1.3 |
| SD18 | 1 | Longfin sanddab | Liver | Lipids | 24.4 | wt% | 0.005 |
| SD18 | 1 | Longfin sanddab | Liver | Manganese | 1.03 | mg/kg | 0.23 |
| SD18 | 1 | Longfin sanddab | Liver | Mercury | 0.178 | mg/kg | 0.012 |
| SD18 | 1 | Longfin sanddab | Liver | o,p-DDE | 17 | ug/kg | 13.3 |
| SD18 | 1 | Longfin sanddab | Liver | o,p-DDT | 3.3 E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | p,p-DDD | 13 E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | p,p-DDE | 970 | ug/kg | 13.3 |
| SD18 | 1 | Longfin sanddab | Liver | p,p-DDT | 18 | ug/kg | 13.3 |
| SD18 | 1 | Longfin sanddab | Liver | PCB 101 | 10 E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 105 | 7.7 E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 110 | 5.8 E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 118 | 34 | ug/kg | 13.3 |
| SD18 | 1 | Longfin sanddab | Liver | PCB 123 | 3.7 E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 128 | 9.6 E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 138 | 53 | ug/kg | 13.3 |
| SD18 | 1 | Longfin sanddab | Liver | PCB 149 | 8.4 E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 151 | 8.1 E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 153/168 | 84 | ug/kg | 13.3 |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD18 | 1 | Longfin sanddab | Liver | PCB 156 | 4.6 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 157 | 1.5 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 158 | 2.7 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 167 | 3 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 170 | 20 | | ug/kg | 13.3 |
| SD18 | 1 | Longfin sanddab | Liver | PCB 177 | 7.1 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 180 | 42 | | ug/kg | 13.3 |
| SD18 | 1 | Longfin sanddab | Liver | PCB 183 | 13 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 187 | 38 | | ug/kg | 13.3 |
| SD18 | 1 | Longfin sanddab | Liver | PCB 194 | 9.1 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 201 | 11 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 206 | 6 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 66 | 4.2 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 74 | 2.5 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | PCB 99 | 21 | | ug/kg | 13.3 |
| SD18 | 1 | Longfin sanddab | Liver | Selenium | 0.93 | | mg/kg | 0.13 |
| SD18 | 1 | Longfin sanddab | Liver | Silver | 0.75 | | mg/kg | 0.62 |
| SD18 | 1 | Longfin sanddab | Liver | Total Solids | 44.5 | | wt% | 0.4 |
| SD18 | 1 | Longfin sanddab | Liver | Trans Nonachlor | 9.6 | E | ug/kg | |
| SD18 | 1 | Longfin sanddab | Liver | Zinc | 20.4 | | mg/kg | 0.58 |
| SD18 | 2 | Longfin sanddab | Liver | Alpha (cis) Chlordane | 8.6 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | Arsenic | 13.4 | | mg/kg | 1.4 |
| SD18 | 2 | Longfin sanddab | Liver | Cadmium | 4.27 | | mg/kg | 0.34 |
| SD18 | 2 | Longfin sanddab | Liver | Copper | 10 | | mg/kg | 0.76 |
| SD18 | 2 | Longfin sanddab | Liver | Hexachlorobenzene | 2.8 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | Iron | 217 | | mg/kg | 1.3 |
| SD18 | 2 | Longfin sanddab | Liver | Lipids | 27.1 | | wt% | 0.005 |
| SD18 | 2 | Longfin sanddab | Liver | Manganese | 1.54 | | mg/kg | 0.23 |
| SD18 | 2 | Longfin sanddab | Liver | Mercury | 0.194 | | mg/kg | 0.012 |
| SD18 | 2 | Longfin sanddab | Liver | o,p-DDE | 18 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | o,p-DDT | 3 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | p,p-DDD | 18 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | p,p-DDE | 1100 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | p,p-DDT | 20 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | PCB 101 | 14 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | PCB 105 | 11 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 110 | 5.7 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 118 | 38 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | PCB 123 | 4.5 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 128 | 12 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 138 | 72 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | PCB 149 | 10 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 151 | 10 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 153/168 | 110 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | PCB 156 | 6.5 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 158 | 5.1 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 167 | 3.8 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 170 | 24 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | PCB 177 | 8.8 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 180 | 55 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | PCB 183 | 16 | | ug/kg | 13.3 |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD18 | 2 | Longfin sanddab | Liver | PCB 187 | 55 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | PCB 194 | 12 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 201 | 16 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | PCB 206 | 7.5 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 66 | 4.7 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 74 | 3.6 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 87 | 2.6 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | PCB 99 | 26 | | ug/kg | 13.3 |
| SD18 | 2 | Longfin sanddab | Liver | Selenium | 1.42 | | mg/kg | 0.13 |
| SD18 | 2 | Longfin sanddab | Liver | Silver | 0.66 | | mg/kg | 0.62 |
| SD18 | 2 | Longfin sanddab | Liver | Total Solids | 41.4 | | wt% | 0.4 |
| SD18 | 2 | Longfin sanddab | Liver | Trans Nonachlor | 15 | E | ug/kg | |
| SD18 | 2 | Longfin sanddab | Liver | Zinc | 29 | | mg/kg | 0.58 |
| SD18 | 3 | Hornyhead turbot | Liver | Aluminum | 13.7 | | mg/kg | 2.6 |
| SD18 | 3 | Hornyhead turbot | Liver | Arsenic | 8.3 | | mg/kg | 1.4 |
| SD18 | 3 | Hornyhead turbot | Liver | Cadmium | 11.2 | | mg/kg | 0.34 |
| SD18 | 3 | Hornyhead turbot | Liver | Copper | 2.59 | | mg/kg | 0.76 |
| SD18 | 3 | Hornyhead turbot | Liver | Iron | 53.8 | | mg/kg | 1.3 |
| SD18 | 3 | Hornyhead turbot | Liver | Lipids | 4.25 | | wt% | 0.005 |
| SD18 | 3 | Hornyhead turbot | Liver | Manganese | 1.7 | | mg/kg | 0.23 |
| SD18 | 3 | Hornyhead turbot | Liver | p,p-DDD | 2.3 | E | ug/kg | |
| SD18 | 3 | Hornyhead turbot | Liver | p,p-DDE | 67 | | ug/kg | 13.3 |
| SD18 | 3 | Hornyhead turbot | Liver | p,p-DDT | 2.2 | E | ug/kg | |
| SD18 | 3 | Hornyhead turbot | Liver | PCB 101 | 1.5 | E | ug/kg | |
| SD18 | 3 | Hornyhead turbot | Liver | PCB 138 | 2.7 | E | ug/kg | |
| SD18 | 3 | Hornyhead turbot | Liver | PCB 153/168 | 6.9 | E | ug/kg | |
| SD18 | 3 | Hornyhead turbot | Liver | PCB 180 | 3.6 | E | ug/kg | |
| SD18 | 3 | Hornyhead turbot | Liver | PCB 187 | 1.7 | E | ug/kg | |
| SD18 | 3 | Hornyhead turbot | Liver | PCB 206 | 1.8 | E | ug/kg | |
| SD18 | 3 | Hornyhead turbot | Liver | PCB 99 | 1.3 | E | ug/kg | |
| SD18 | 3 | Hornyhead turbot | Liver | Selenium | 0.52 | | mg/kg | 0.13 |
| SD18 | 3 | Hornyhead turbot | Liver | Total Solids | 22.5 | | wt% | 0.4 |
| SD18 | 3 | Hornyhead turbot | Liver | Zinc | 36.3 | | mg/kg | 0.58 |
| SD19 | 1 | Longfin sanddab | Liver | Alpha (cis) Chlordane | 7.7 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | Aluminum | 7.3 | | mg/kg | 2.6 |
| SD19 | 1 | Longfin sanddab | Liver | Arsenic | 14.8 | | mg/kg | 1.4 |
| SD19 | 1 | Longfin sanddab | Liver | Cadmium | 1.07 | | mg/kg | 0.34 |
| SD19 | 1 | Longfin sanddab | Liver | Copper | 5.16 | | mg/kg | 0.76 |
| SD19 | 1 | Longfin sanddab | Liver | Hexachlorobenzene | 2.7 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | Iron | 124 | | mg/kg | 1.3 |
| SD19 | 1 | Longfin sanddab | Liver | Lipids | 27.1 | | wt% | 0.005 |
| SD19 | 1 | Longfin sanddab | Liver | Manganese | 1.83 | | mg/kg | 0.23 |
| SD19 | 1 | Longfin sanddab | Liver | Mercury | 0.212 | | mg/kg | 0.012 |
| SD19 | 1 | Longfin sanddab | Liver | o,p-DDD | 3.7 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | o,p-DDE | 25 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | o,p-DDT | 3 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | p,p-DDD | 36 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | p,p-DDE | 1100 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | p,p-DDT | 10 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 101 | 15 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | PCB 105 | 7.3 | E | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD19 | 1 | Longfin sanddab | Liver | PCB 110 | 13 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 118 | 33 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | PCB 123 | 4.3 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 128 | 9.2 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 138 | 42 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | PCB 149 | 14 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | PCB 151 | 7.4 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 153/168 | 68 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | PCB 156 | 4.4 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 167 | 2.5 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 170 | 15 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | PCB 177 | 6.2 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 180 | 30 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | PCB 183 | 9.5 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 187 | 29 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | PCB 194 | 6.5 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 201 | 8.8 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 206 | 5.6 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 66 | 5.4 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 70 | 3 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 74 | 3.6 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 87 | 4.5 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | PCB 99 | 21 | | ug/kg | 13.3 |
| SD19 | 1 | Longfin sanddab | Liver | Selenium | 0.92 | | mg/kg | 0.13 |
| SD19 | 1 | Longfin sanddab | Liver | Silver | 0.69 | | mg/kg | 0.62 |
| SD19 | 1 | Longfin sanddab | Liver | Total Solids | 47.2 | | wt% | 0.4 |
| SD19 | 1 | Longfin sanddab | Liver | Trans Nonachlor | 7.6 | E | ug/kg | |
| SD19 | 1 | Longfin sanddab | Liver | Zinc | 27.7 | | mg/kg | 0.58 |
| SD19 | 2 | Longfin sanddab | Liver | Alpha (cis) Chlordane | 11 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | Aluminum | 5.3 | | mg/kg | 2.6 |
| SD19 | 2 | Longfin sanddab | Liver | Arsenic | 7.4 | | mg/kg | 1.4 |
| SD19 | 2 | Longfin sanddab | Liver | Cadmium | 1.9 | | mg/kg | 0.34 |
| SD19 | 2 | Longfin sanddab | Liver | Cis Nonachlor | 11 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | Copper | 0.89 | | mg/kg | 0.76 |
| SD19 | 2 | Longfin sanddab | Liver | Hexachlorobenzene | 1.9 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | Iron | 134 | | mg/kg | 1.3 |
| SD19 | 2 | Longfin sanddab | Liver | Lipids | 17.1 | | wt% | 0.005 |
| SD19 | 2 | Longfin sanddab | Liver | Manganese | 2.19 | | mg/kg | 0.23 |
| SD19 | 2 | Longfin sanddab | Liver | Mercury | 0.234 | | mg/kg | 0.012 |
| SD19 | 2 | Longfin sanddab | Liver | o,p-DDE | 69 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | o,p-DDT | 3.7 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | p,p-DDD | 30 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | p,p-DDE | 1470 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | p,p-DDT | 26 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | PCB 101 | 15 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | PCB 105 | 9.2 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 110 | 5 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 118 | 42 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | PCB 123 | 4.2 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 128 | 12 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 138 | 65 | | ug/kg | 13.3 |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD19 | 2 | Longfin sanddab | Liver | PCB 149 | 11 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 151 | 9 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 153/168 | 89 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | PCB 156 | 5.6 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 158 | 4.3 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 167 | 3.8 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 169 | 4.2 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 170 | 18 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | PCB 177 | 9.3 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 180 | 43 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | PCB 183 | 14 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | PCB 187 | 40 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | PCB 194 | 11 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 201 | 13 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 206 | 6.9 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 49 | 1.9 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 52 | 4.8 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 66 | 5.6 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 70 | 2.9 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 74 | 4.1 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 87 | 3.1 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | PCB 99 | 29 | | ug/kg | 13.3 |
| SD19 | 2 | Longfin sanddab | Liver | Selenium | 0.91 | | mg/kg | 0.13 |
| SD19 | 2 | Longfin sanddab | Liver | Total Solids | 43.4 | | wt% | 0.4 |
| SD19 | 2 | Longfin sanddab | Liver | Trans Nonachlor | 14 | E | ug/kg | |
| SD19 | 2 | Longfin sanddab | Liver | Zinc | 24 | | mg/kg | 0.58 |
| SD19 | 3 | Hornyhead turbot | Liver | Aluminum | 8.7 | | mg/kg | 2.6 |
| SD19 | 3 | Hornyhead turbot | Liver | Arsenic | 11.2 | | mg/kg | 1.4 |
| SD19 | 3 | Hornyhead turbot | Liver | Cadmium | 9 | | mg/kg | 0.34 |
| SD19 | 3 | Hornyhead turbot | Liver | Copper | 30.6 | | mg/kg | 0.76 |
| SD19 | 3 | Hornyhead turbot | Liver | Iron | 56 | | mg/kg | 1.3 |
| SD19 | 3 | Hornyhead turbot | Liver | Lipids | 5 | | wt% | 0.005 |
| SD19 | 3 | Hornyhead turbot | Liver | Manganese | 2.32 | | mg/kg | 0.23 |
| SD19 | 3 | Hornyhead turbot | Liver | Mercury | 0.152 | | mg/kg | 0.012 |
| SD19 | 3 | Hornyhead turbot | Liver | p,p-DDD | 3.2 | E | ug/kg | |
| SD19 | 3 | Hornyhead turbot | Liver | p,p-DDE | 99 | | ug/kg | 13.3 |
| SD19 | 3 | Hornyhead turbot | Liver | PCB 101 | 2.6 | E | ug/kg | |
| SD19 | 3 | Hornyhead turbot | Liver | PCB 118 | 3.1 | E | ug/kg | |
| SD19 | 3 | Hornyhead turbot | Liver | PCB 138 | 4.9 | E | ug/kg | |
| SD19 | 3 | Hornyhead turbot | Liver | PCB 149 | 2.3 | E | ug/kg | |
| SD19 | 3 | Hornyhead turbot | Liver | PCB 153/168 | 7.9 | E | ug/kg | |
| SD19 | 3 | Hornyhead turbot | Liver | PCB 180 | 4.3 | E | ug/kg | |
| SD19 | 3 | Hornyhead turbot | Liver | PCB 187 | 4 | E | ug/kg | |
| SD19 | 3 | Hornyhead turbot | Liver | PCB 206 | 1.9 | E | ug/kg | |
| SD19 | 3 | Hornyhead turbot | Liver | PCB 99 | 2.3 | E | ug/kg | |
| SD19 | 3 | Hornyhead turbot | Liver | Selenium | 0.55 | | mg/kg | 0.13 |
| SD19 | 3 | Hornyhead turbot | Liver | Total Solids | 24.8 | | wt% | 0.4 |
| SD19 | 3 | Hornyhead turbot | Liver | Zinc | 43.2 | | mg/kg | 0.58 |
| SD20 | 1 | Longfin sanddab | Liver | Alpha (cis) Chlordane | 5.8 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | Aluminum | 15.1 | | mg/kg | 2.6 |
| SD20 | 1 | Longfin sanddab | Liver | Arsenic | 8.6 | | mg/kg | 1.4 |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD20 | 1 | Longfin sanddab | Liver | Copper | 13.8 | | mg/kg | 0.76 |
| SD20 | 1 | Longfin sanddab | Liver | Hexachlorobenzene | 2.2 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | Iron | 111 | | mg/kg | 1.3 |
| SD20 | 1 | Longfin sanddab | Liver | Lipids | 24.2 | | wt% | 0.005 |
| SD20 | 1 | Longfin sanddab | Liver | Manganese | 1.89 | | mg/kg | 0.23 |
| SD20 | 1 | Longfin sanddab | Liver | o,p-DDE | 29 | | ug/kg | 13.3 |
| SD20 | 1 | Longfin sanddab | Liver | o,p-DDT | 2.8 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | p,p-DDD | 14 | | ug/kg | 13.3 |
| SD20 | 1 | Longfin sanddab | Liver | p,p-DDE | 870 | | ug/kg | 13.3 |
| SD20 | 1 | Longfin sanddab | Liver | p,p-DDT | 17 | | ug/kg | 13.3 |
| SD20 | 1 | Longfin sanddab | Liver | PCB 101 | 13 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 105 | 7.5 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 110 | 9.7 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 118 | 35 | | ug/kg | 13.3 |
| SD20 | 1 | Longfin sanddab | Liver | PCB 123 | 4.1 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 128 | 8.5 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 138 | 47 | | ug/kg | 13.3 |
| SD20 | 1 | Longfin sanddab | Liver | PCB 149 | 9.2 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 151 | 8.9 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 153/168 | 74 | | ug/kg | 13.3 |
| SD20 | 1 | Longfin sanddab | Liver | PCB 156 | 4.9 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 158 | 2.9 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 167 | 2.9 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 177 | 5 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 180 | 32 | | ug/kg | 13.3 |
| SD20 | 1 | Longfin sanddab | Liver | PCB 183 | 9.8 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 187 | 30 | | ug/kg | 13.3 |
| SD20 | 1 | Longfin sanddab | Liver | PCB 194 | 6.9 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 206 | 4.2 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 66 | 4.9 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 70 | 3 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 74 | 4 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 87 | 2.5 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | PCB 99 | 20 | | ug/kg | 13.3 |
| SD20 | 1 | Longfin sanddab | Liver | Selenium | 0.89 | | mg/kg | 0.13 |
| SD20 | 1 | Longfin sanddab | Liver | Total Solids | 41.4 | | wt% | 0.4 |
| SD20 | 1 | Longfin sanddab | Liver | Trans Nonachlor | 11 | E | ug/kg | |
| SD20 | 1 | Longfin sanddab | Liver | Zinc | 24.1 | | mg/kg | 0.58 |
| SD20 | 2 | English sole | Liver | Aluminum | 3.9 | | mg/kg | 2.6 |
| SD20 | 2 | English sole | Liver | Arsenic | 20.8 | | mg/kg | 1.4 |
| SD20 | 2 | English sole | Liver | Cadmium | 0.8 | | mg/kg | 0.34 |
| SD20 | 2 | English sole | Liver | Copper | 7.61 | | mg/kg | 0.76 |
| SD20 | 2 | English sole | Liver | Iron | 256 | | mg/kg | 1.3 |
| SD20 | 2 | English sole | Liver | Lipids | 3.31 | | wt% | 0.005 |
| SD20 | 2 | English sole | Liver | Manganese | 2.63 | | mg/kg | 0.23 |
| SD20 | 2 | English sole | Liver | p,p-DDD | 1.4 | E | ug/kg | |
| SD20 | 2 | English sole | Liver | p,p-DDE | 48 | | ug/kg | 13.3 |
| SD20 | 2 | English sole | Liver | PCB 101 | 2.8 | E | ug/kg | |
| SD20 | 2 | English sole | Liver | PCB 118 | 2.6 | E | ug/kg | |
| SD20 | 2 | English sole | Liver | PCB 138 | 4.2 | E | ug/kg | |
| SD20 | 2 | English sole | Liver | PCB 149 | 3.1 | E | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD20 | 2 | English sole | Liver | PCB 153/168 | 5.4 | E | ug/kg | |
| SD20 | 2 | English sole | Liver | PCB 180 | 1.4 | E | ug/kg | |
| SD20 | 2 | English sole | Liver | PCB 187 | 1.8 | E | ug/kg | |
| SD20 | 2 | English sole | Liver | PCB 206 | 2.1 | E | ug/kg | |
| SD20 | 2 | English sole | Liver | PCB 99 | 2 | E | ug/kg | |
| SD20 | 2 | English sole | Liver | Selenium | 0.77 | | mg/kg | 0.13 |
| SD20 | 2 | English sole | Liver | Total Solids | 25.3 | | wt% | 0.4 |
| SD20 | 2 | English sole | Liver | Zinc | 44.1 | | mg/kg | 0.58 |
| SD20 | 3 | Ca. scorpionfish | Liver | Aluminum | 25.8 | | mg/kg | 2.6 |
| SD20 | 3 | Ca. scorpionfish | Liver | Chromium | 0.39 | | mg/kg | 0.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | Copper | 16.7 | | mg/kg | 0.76 |
| SD20 | 3 | Ca. scorpionfish | Liver | Hexachlorobenzene | 1.5 | | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | Iron | 70.9 | | mg/kg | 1.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | Lipids | 23.3 | | wt% | 0.005 |
| SD20 | 3 | Ca. scorpionfish | Liver | Manganese | 0.63 | | mg/kg | 0.23 |
| SD20 | 3 | Ca. scorpionfish | Liver | o,p-DDE | 3.25 | | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | p,p-DDD | 31.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | p,p-DDE | 2170 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | p,p-DDT | 16.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 101 | 27.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 105 | 15 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 110 | 16 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 118 | 51.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 123 | 5.8 | | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 128 | 17.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 138 | 90.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 149 | 15.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 151 | 17 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 153/168 | 165 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 156 | 10.3 | | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 157 | 1 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 158 | 7.1 | | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 167 | 4.1 | | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 170 | 30 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 177 | 16.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 180 | 75.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 183 | 21 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 187 | 65.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 194 | 11 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 201 | 19.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 206 | 6.1 | | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 66 | 7.15 | | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 74 | 4.75 | | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 87 | 7.2 | | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 99 | 27.5 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | Selenium | 0.865 | | mg/kg | 0.17 |
| SD20 | 3 | Ca. scorpionfish | Liver | Total Solids | 42.7 | | wt% | 0.4 |
| SD20 | 3 | Ca. scorpionfish | Liver | Trans Nonachlor | 17 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | Zinc | 102 | | mg/kg | 0.58 |
| SD21 | 1 | Longfin sanddab | Liver | Aluminum | 3.7 | | mg/kg | 2.6 |
| SD21 | 1 | Longfin sanddab | Liver | Arsenic | 4.4 | | mg/kg | 1.4 |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD21 | 1 | Longfin sanddab | Liver | Copper | 5.06 | | mg/kg | 0.76 |
| SD21 | 1 | Longfin sanddab | Liver | Hexachlorobenzene | 2.3 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | Iron | 91.6 | | mg/kg | 1.3 |
| SD21 | 1 | Longfin sanddab | Liver | Lipids | 24.6 | | wt% | 0.005 |
| SD21 | 1 | Longfin sanddab | Liver | Manganese | 1.63 | | mg/kg | 0.23 |
| SD21 | 1 | Longfin sanddab | Liver | Mercury | 0.0065 | | mg/kg | 0.012 |
| SD21 | 1 | Longfin sanddab | Liver | o,p-DDD | 1.4 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | o,p-DDE | 14 | | ug/kg | 13.3 |
| SD21 | 1 | Longfin sanddab | Liver | p,p-DDD | 12 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | p,p-DDE | 710 | | ug/kg | 13.3 |
| SD21 | 1 | Longfin sanddab | Liver | p,p-DDT | 12 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 101 | 13 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 105 | 9.3 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 110 | 7.9 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 118 | 43 | | ug/kg | 13.3 |
| SD21 | 1 | Longfin sanddab | Liver | PCB 123 | 5.2 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 128 | 11 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 138 | 69 | | ug/kg | 13.3 |
| SD21 | 1 | Longfin sanddab | Liver | PCB 149 | 12 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 151 | 10 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 153/168 | 98 | | ug/kg | 13.3 |
| SD21 | 1 | Longfin sanddab | Liver | PCB 156 | 6.3 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 158 | 4.6 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 167 | 3 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 177 | 8.4 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 180 | 50 | | ug/kg | 13.3 |
| SD21 | 1 | Longfin sanddab | Liver | PCB 183 | 14 | | ug/kg | 13.3 |
| SD21 | 1 | Longfin sanddab | Liver | PCB 187 | 48 | | ug/kg | 13.3 |
| SD21 | 1 | Longfin sanddab | Liver | PCB 194 | 13 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 201 | 16 | | ug/kg | 13.3 |
| SD21 | 1 | Longfin sanddab | Liver | PCB 206 | 7.7 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 66 | 3.2 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 74 | 3.3 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 87 | 3 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | PCB 99 | 27 | | ug/kg | 13.3 |
| SD21 | 1 | Longfin sanddab | Liver | Selenium | 0.75 | | mg/kg | 0.13 |
| SD21 | 1 | Longfin sanddab | Liver | Total Solids | 44.4 | | wt% | 0.4 |
| SD21 | 1 | Longfin sanddab | Liver | Trans Nonachlor | 8.2 | E | ug/kg | |
| SD21 | 1 | Longfin sanddab | Liver | Zinc | 23 | | mg/kg | 0.58 |
| SD21 | 2 | Hornyhead turbot | Liver | Arsenic | 1.4 | | mg/kg | 1.4 |
| SD21 | 2 | Hornyhead turbot | Liver | Cadmium | 3.09 | | mg/kg | 0.34 |
| SD21 | 2 | Hornyhead turbot | Liver | Copper | 10.6 | | mg/kg | 0.76 |
| SD21 | 2 | Hornyhead turbot | Liver | Iron | 38.3 | | mg/kg | 1.3 |
| SD21 | 2 | Hornyhead turbot | Liver | Lipids | 6.7 | | wt% | 0.005 |
| SD21 | 2 | Hornyhead turbot | Liver | Manganese | 2.25 | | mg/kg | 0.23 |
| SD21 | 2 | Hornyhead turbot | Liver | Mercury | 0.014 | | mg/kg | 0.012 |
| SD21 | 2 | Hornyhead turbot | Liver | p,p-DDD | 2.8 | E | ug/kg | |
| SD21 | 2 | Hornyhead turbot | Liver | p,p-DDE | 75 | | ug/kg | 13.3 |
| SD21 | 2 | Hornyhead turbot | Liver | p,p-DDT | 2.3 | E | ug/kg | |
| SD21 | 2 | Hornyhead turbot | Liver | PCB 101 | 3.8 | E | ug/kg | |
| SD21 | 2 | Hornyhead turbot | Liver | PCB 105 | 1.4 | E | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD21 | 2 | Hornyhead turbot | Liver | PCB 118 | 5.7 | E | ug/kg | |
| SD21 | 2 | Hornyhead turbot | Liver | PCB 138 | 9.9 | E | ug/kg | |
| SD21 | 2 | Hornyhead turbot | Liver | PCB 149 | 3.1 | E | ug/kg | |
| SD21 | 2 | Hornyhead turbot | Liver | PCB 153/168 | 13 | E | ug/kg | |
| SD21 | 2 | Hornyhead turbot | Liver | PCB 180 | 4.9 | E | ug/kg | |
| SD21 | 2 | Hornyhead turbot | Liver | PCB 187 | 5.1 | E | ug/kg | |
| SD21 | 2 | Hornyhead turbot | Liver | PCB 206 | 2.4 | E | ug/kg | |
| SD21 | 2 | Hornyhead turbot | Liver | PCB 99 | 4.5 | E | ug/kg | |
| SD21 | 2 | Hornyhead turbot | Liver | Selenium | 0.38 | | mg/kg | 0.13 |
| SD21 | 2 | Hornyhead turbot | Liver | Total Solids | 22.9 | | wt% | 0.4 |
| SD21 | 2 | Hornyhead turbot | Liver | Zinc | 40.6 | | mg/kg | 0.58 |
| SD21 | 3 | Hornyhead turbot | Liver | Cadmium | 1.72 | | mg/kg | 0.34 |
| SD21 | 3 | Hornyhead turbot | Liver | Copper | 6.54 | | mg/kg | 0.76 |
| SD21 | 3 | Hornyhead turbot | Liver | Iron | 58.3 | | mg/kg | 1.3 |
| SD21 | 3 | Hornyhead turbot | Liver | Lipids | 3.57 | | wt% | 0.005 |
| SD21 | 3 | Hornyhead turbot | Liver | Manganese | 2.22 | | mg/kg | 0.23 |
| SD21 | 3 | Hornyhead turbot | Liver | Mercury | 0.0195 | | mg/kg | 0.012 |
| SD21 | 3 | Hornyhead turbot | Liver | p,p-DDD | 2.4 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | p,p-DDE | 88 | | ug/kg | 13.3 |
| SD21 | 3 | Hornyhead turbot | Liver | p,p-DDT | 3.4 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | PCB 101 | 2.4 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | PCB 118 | 3.6 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | PCB 138 | 6.2 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | PCB 153/168 | 11 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | PCB 180 | 5.6 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | PCB 183 | 1.8 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | PCB 187 | 6.4 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | PCB 194 | 1.5 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | PCB 206 | 2.8 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | PCB 99 | 3.2 | E | ug/kg | |
| SD21 | 3 | Hornyhead turbot | Liver | Selenium | 0.6 | | mg/kg | 0.13 |
| SD21 | 3 | Hornyhead turbot | Liver | Total Solids | 23.8 | | wt% | 0.4 |
| SD21 | 3 | Hornyhead turbot | Liver | Zinc | 33 | | mg/kg | 0.58 |

## Appendix C.3
October 2002

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| RF3 | 1 | Vermilion rockfish | Muscle | Hexachlorobenzene | 0.2 | E | ug/kg | |
| RF3 | 1 | Vermilion rockfish | Muscle | Lipids | 1.31 | | wt% | 0.005 |
| RF3 | 1 | Vermilion rockfish | Muscle | Mercury | 0.0565 | | mg/kg | 0.03 |
| RF3 | 1 | Vermilion rockfish | Muscle | p,p-DDD | 0.2 | E | ug/kg | |
| RF3 | 1 | Vermilion rockfish | Muscle | p,p-DDE | 4.8 | | ug/kg | 1.33 |
| RF3 | 1 | Vermilion rockfish | Muscle | PCB 101 | 0.2 | E | ug/kg | |
| RF3 | 1 | Vermilion rockfish | Muscle | PCB 118 | 0.2 | E | ug/kg | |
| RF3 | 1 | Vermilion rockfish | Muscle | PCB 138 | 0.2 | E | ug/kg | |
| RF3 | 1 | Vermilion rockfish | Muscle | PCB 153/168 | 0.4 | E | ug/kg | |
| RF3 | 1 | Vermilion rockfish | Muscle | PCB 206 | 0.1 | E | ug/kg | |
| RF3 | 1 | Vermilion rockfish | Muscle | PCB 99 | 0.2 | E | ug/kg | |
| RF3 | 1 | Vermilion rockfish | Muscle | Selenium | 0.17 | | mg/kg | 0.06 |
| RF3 | 1 | Vermilion rockfish | Muscle | Total Solids | 22.7 | | wt% | 0.4 |
| RF3 | 1 | Vermilion rockfish | Muscle | Zinc | 1.78 | | mg/kg | 0.58 |
| RF3 | 2 | Brown rockfish | Muscle | Arsenic | 2.4 | | mg/kg | 1.4 |
| RF3 | 2 | Brown rockfish | Muscle | Chromium | 0.33 | | mg/kg | 0.3 |
| RF3 | 2 | Brown rockfish | Muscle | Iron | 5.6 | | mg/kg | 1.3 |
| RF3 | 2 | Brown rockfish | Muscle | Lipids | 1.03 | | wt% | 0.005 |
| RF3 | 2 | Brown rockfish | Muscle | Mercury | 0.0853 | | mg/kg | 0.03 |
| RF3 | 2 | Brown rockfish | Muscle | p,p-DDE | 4.9 | | ug/kg | 1.33 |
| RF3 | 2 | Brown rockfish | Muscle | PCB 118 | 0.1 | E | ug/kg | |
| RF3 | 2 | Brown rockfish | Muscle | PCB 138 | 0.2 | E | ug/kg | |
| RF3 | 2 | Brown rockfish | Muscle | PCB 153/168 | 0.3 | E | ug/kg | |
| RF3 | 2 | Brown rockfish | Muscle | PCB 206 | 0.1 | E | ug/kg | |
| RF3 | 2 | Brown rockfish | Muscle | Selenium | 0.217 | | mg/kg | 0.06 |
| RF3 | 2 | Brown rockfish | Muscle | Total Solids | 20.5 | | wt% | 0.4 |
| RF3 | 2 | Brown rockfish | Muscle | Zinc | 1.42 | | mg/kg | 0.58 |
| RF3 | 3 | Vermilion rockfish | Muscle | Arsenic | 1.4 | | mg/kg | 1.4 |
| RF3 | 3 | Vermilion rockfish | Muscle | Hexachlorobenzene | 0.1 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | Lipids | 1.07 | | wt% | 0.005 |
| RF3 | 3 | Vermilion rockfish | Muscle | Mercury | 0.0437 | | mg/kg | 0.03 |
| RF3 | 3 | Vermilion rockfish | Muscle | p,p-DDD | 0.2 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | p,p-DDE | 4 | | ug/kg | 1.33 |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 101 | 0.3 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 105 | 0.1 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 110 | 0.2 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 118 | 0.3 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 138 | 0.2 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 149 | 0.2 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 153/168 | 0.5 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 180 | 0.2 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 187 | 0.2 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 206 | 0.2 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 28 | 0.1 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 70 | 0.1 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 74 | 0.1 | E | ug/kg | |
| RF3 | 3 | Vermilion rockfish | Muscle | PCB 99 | 0.3 | E | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| RF3 | 3 | Vermilion rockfish | Muscle | Selenium | 0.24 | | mg/kg | 0.06 |
| RF3 | 3 | Vermilion rockfish | Muscle | Total Solids | 22.4 | | wt% | 0.4 |
| RF3 | 3 | Vermilion rockfish | Muscle | Zinc | 1.93 | | mg/kg | 0.58 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Arsenic | 2.5 | | mg/kg | 1.4 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Copper | 2.74 | | mg/kg | 0.76 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Lipids | 0.33 | | wt% | 0.005 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Mercury | 0.265 | | mg/kg | 0.03 |
| RF4 | 1 | Ca. scorpionfish | Muscle | p,p-DDE | 3.2 | | ug/kg | 1.33 |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 118 | 0.2 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 153/168 | 0.3 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | PCB 206 | 0.1 | E | ug/kg | |
| RF4 | 1 | Ca. scorpionfish | Muscle | Selenium | 0.225 | | mg/kg | 0.06 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Total Solids | 21 | | wt% | 0.4 |
| RF4 | 1 | Ca. scorpionfish | Muscle | Zinc | 1.92 | | mg/kg | 0.58 |
| RF4 | 2 | Ca. scorpionfish | Muscle | Arsenic | 2.5 | | mg/kg | 1.4 |
| RF4 | 2 | Ca. scorpionfish | Muscle | Copper | 0.77 | | mg/kg | 0.76 |
| RF4 | 2 | Ca. scorpionfish | Muscle | Hexachlorobenzene | 0.2 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | Lipids | 0.16 | | wt% | 0.005 |
| RF4 | 2 | Ca. scorpionfish | Muscle | Mercury | 0.198 | | mg/kg | 0.03 |
| RF4 | 2 | Ca. scorpionfish | Muscle | p,p-DDD | 0.2 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | p,p-DDE | 9.7 | | ug/kg | 1.33 |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 101 | 0.2 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 105 | 0.2 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 118 | 0.4 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 138 | 0.3 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 153/168 | 0.8 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 180 | 0.6 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 187 | 0.3 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 194 | 0.3 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 206 | 0.3 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | PCB 99 | 0.2 | E | ug/kg | |
| RF4 | 2 | Ca. scorpionfish | Muscle | Selenium | 0.156 | | mg/kg | 0.06 |
| RF4 | 2 | Ca. scorpionfish | Muscle | Total Solids | 20.8 | | wt% | 0.4 |
| RF4 | 2 | Ca. scorpionfish | Muscle | Zinc | 1.92 | | mg/kg | 0.58 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Chromium | 0.32 | | mg/kg | 0.3 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Hexachlorobenzene | 0.2 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | Iron | 4 | | mg/kg | 1.3 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Lipids | 0.97 | | wt% | 0.005 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Mercury | 0.187 | | mg/kg | 0.03 |
| RF4 | 3 | Ca. scorpionfish | Muscle | p,p-DDD | 0.5 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | p,p-DDE | 20 | | ug/kg | 1.33 |
| RF4 | 3 | Ca. scorpionfish | Muscle | p,p-DDT | 0.4 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 101 | 0.4 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 105 | 0.3 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 110 | 0.3 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 118 | 0.7 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 138 | 0.8 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 149 | 0.2 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 151 | 0.2 | E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 153/168 | 1.5 | | ug/kg | 1.33 |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 180 | 0.6 | E | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | Units | MDL |
|---|---|---|---|---|---|---|---|
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 187 | 0.4 E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 194 | 0.2 E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 206 | 0.1 E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | PCB 99 | 0.4 E | ug/kg | |
| RF4 | 3 | Ca. scorpionfish | Muscle | Selenium | 0.223 | mg/kg | 0.06 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Total Solids | 21.2 | wt% | 0.4 |
| RF4 | 3 | Ca. scorpionfish | Muscle | Zinc | 3.92 | mg/kg | 0.58 |
| SD15 | 1 | Ca. scorpionfish | Liver | Aluminum | 16 | mg/kg | 2.6 |
| SD15 | 1 | Ca. scorpionfish | Liver | Arsenic | 3 | mg/kg | 1.4 |
| SD15 | 1 | Ca. scorpionfish | Liver | Cadmium | 4.29 | mg/kg | 0.34 |
| SD15 | 1 | Ca. scorpionfish | Liver | Copper | 32 | mg/kg | 0.76 |
| SD15 | 1 | Ca. scorpionfish | Liver | Hexachlorobenzene | 2.9 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | Iron | 141 | mg/kg | 1.3 |
| SD15 | 1 | Ca. scorpionfish | Liver | Lipids | 16.9 | wt% | 0.005 |
| SD15 | 1 | Ca. scorpionfish | Liver | Manganese | 0.42 | mg/kg | 0.23 |
| SD15 | 1 | Ca. scorpionfish | Liver | Mercury | 0.231 | mg/kg | 0.03 |
| SD15 | 1 | Ca. scorpionfish | Liver | p,p-DDD | 6.1 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | p,p-DDE | 470 | ug/kg | 13.3 |
| SD15 | 1 | Ca. scorpionfish | Liver | p,p-DDT | 6.2 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 101 | 11 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 105 | 7.3 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 110 | 5.8 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 118 | 23 | ug/kg | 13.3 |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 123 | 2.9 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 128 | 5 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 138 | 28 | ug/kg | 13.3 |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 149 | 5.5 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 151 | 5.2 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 153/168 | 52 | ug/kg | 13.3 |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 156 | 2.8 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 157 | 1.5 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 158 | 2.6 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 167 | 2 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 177 | 3.3 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 180 | 24 | ug/kg | 13.3 |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 183 | 6.7 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 187 | 19 | ug/kg | 13.3 |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 194 | 6.5 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 206 | 3.8 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 28 | 4.8 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 66 | 3.7 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 70 | 1.7 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 74 | 2.3 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 87 | 3.1 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | PCB 99 | 9.8 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | Selenium | 0.611 | mg/kg | 0.06 |
| SD15 | 1 | Ca. scorpionfish | Liver | Total Solids | 50.9 | wt% | 0.4 |
| SD15 | 1 | Ca. scorpionfish | Liver | Trans Nonachlor | 11 E | ug/kg | |
| SD15 | 1 | Ca. scorpionfish | Liver | Zinc | 49.7 | mg/kg | 0.58 |
| SD15 | 2 | Ca. scorpionfish | Liver | Alpha (cis) Chlordane | 5.2 E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | Aluminum | 18 | mg/kg | 2.6 |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD15 | 2 | Ca. scorpionfish | Liver | Arsenic | 4.6 | | mg/kg | 1.4 |
| SD15 | 2 | Ca. scorpionfish | Liver | BHC, Alpha isomer | 20 | | ug/kg | 20 |
| SD15 | 2 | Ca. scorpionfish | Liver | BHC, Beta isomer | 31 | | ug/kg | 20 |
| SD15 | 2 | Ca. scorpionfish | Liver | Cadmium | 0.72 | | mg/kg | 0.34 |
| SD15 | 2 | Ca. scorpionfish | Liver | Copper | 37.1 | | mg/kg | 0.76 |
| SD15 | 2 | Ca. scorpionfish | Liver | Gamma (trans) Chlordane | 6 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | Heptachlor | 8.6 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | Hexachlorobenzene | 1.8 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | Iron | 99.6 | | mg/kg | 1.3 |
| SD15 | 2 | Ca. scorpionfish | Liver | Lipids | 24.5 | | wt% | 0.005 |
| SD15 | 2 | Ca. scorpionfish | Liver | Manganese | 0.34 | | mg/kg | 0.23 |
| SD15 | 2 | Ca. scorpionfish | Liver | Mercury | 0.155 | | mg/kg | 0.03 |
| SD15 | 2 | Ca. scorpionfish | Liver | p,p-DDD | 2.3 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | p,p-DDE | 110 | | ug/kg | 13.3 |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 101 | 2.5 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 118 | 4.5 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 138 | 5.6 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 151 | 1.6 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 153/168 | 8.4 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 180 | 5 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 187 | 4 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 194 | 1.6 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 206 | 1.6 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | PCB 99 | 2 | E | ug/kg | |
| SD15 | 2 | Ca. scorpionfish | Liver | Selenium | 0.943 | | mg/kg | 0.06 |
| SD15 | 2 | Ca. scorpionfish | Liver | Total Solids | 44.9 | | wt% | 0.4 |
| SD15 | 2 | Ca. scorpionfish | Liver | Zinc | 76.8 | | mg/kg | 0.58 |
| SD15 | 3 | Ca. scorpionfish | Liver | Aluminum | 13.7 | | mg/kg | 2.6 |
| SD15 | 3 | Ca. scorpionfish | Liver | Arsenic | 7.4 | | mg/kg | 1.4 |
| SD15 | 3 | Ca. scorpionfish | Liver | Cadmium | 0.69 | | mg/kg | 0.34 |
| SD15 | 3 | Ca. scorpionfish | Liver | Copper | 27.4 | | mg/kg | 0.76 |
| SD15 | 3 | Ca. scorpionfish | Liver | Hexachlorobenzene | 4.3 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | Iron | 80.7 | | mg/kg | 1.3 |
| SD15 | 3 | Ca. scorpionfish | Liver | Lipids | 39.1 | | wt% | 0.005 |
| SD15 | 3 | Ca. scorpionfish | Liver | Mercury | 0.105 | | mg/kg | 0.03 |
| SD15 | 3 | Ca. scorpionfish | Liver | Nickel | 0.98 | | mg/kg | 0.79 |
| SD15 | 3 | Ca. scorpionfish | Liver | p,p-DDD | 5.5 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | p,p-DDE | 350 | | ug/kg | 13.3 |
| SD15 | 3 | Ca. scorpionfish | Liver | p,p-DDT | 5.3 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 101 | 6.1 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 105 | 4.3 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 110 | 3.3 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 118 | 14 | | ug/kg | 13.3 |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 128 | 3.2 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 138 | 18 | | ug/kg | 13.3 |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 149 | 2.8 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 151 | 2.5 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 153/168 | 32 | | ug/kg | 13.3 |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 156 | 1.3 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 158 | 1.1 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 177 | 1.6 | E | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 180 | 16 | | ug/kg | 13.3 |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 183 | 4.1 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 187 | 11 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 194 | 4.3 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 206 | 4 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 66 | 2.2 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 70 | 1.4 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 87 | 1.6 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | PCB 99 | 6.4 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | Selenium | 0.421 | | mg/kg | 0.06 |
| SD15 | 3 | Ca. scorpionfish | Liver | Total Solids | 62.2 | | wt% | 0.4 |
| SD15 | 3 | Ca. scorpionfish | Liver | Trans Nonachlor | 8.8 | E | ug/kg | |
| SD15 | 3 | Ca. scorpionfish | Liver | Zinc | 83.1 | | mg/kg | 0.58 |
| SD16 | 1 | Ca. scorpionfish | Liver | Alpha (cis) Chlordane | 8.5 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | Aluminum | 8.95 | | mg/kg | 2.6 |
| SD16 | 1 | Ca. scorpionfish | Liver | Arsenic | 1.45 | | mg/kg | 1.4 |
| SD16 | 1 | Ca. scorpionfish | Liver | Cadmium | 0.49 | | mg/kg | 0.34 |
| SD16 | 1 | Ca. scorpionfish | Liver | Copper | 39.3 | | mg/kg | 0.76 |
| SD16 | 1 | Ca. scorpionfish | Liver | Hexachlorobenzene | 4.7 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | Iron | 226 | | mg/kg | 1.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | Lipids | 39.5 | | wt% | 0.005 |
| SD16 | 1 | Ca. scorpionfish | Liver | Manganese | 0.315 | | mg/kg | 0.23 |
| SD16 | 1 | Ca. scorpionfish | Liver | Mercury | 0.147 | | mg/kg | 0.03 |
| SD16 | 1 | Ca. scorpionfish | Liver | o,p-DDE | 55 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | o,p-DDT | 2.7 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | p,p-DDD | 110 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | p,p-DDE | 5400 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | p,p-DDT | 33 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 101 | 40 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 105 | 27 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 110 | 22 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 118 | 73 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 119 | 1.5 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 123 | 7.6 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 128 | 17 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 138 | 88 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 149 | 17 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 151 | 12 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 153/168 | 150 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 156 | 11 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 157 | 3.9 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 158 | 8.8 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 167 | 6.4 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 170 | 30 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 177 | 13 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 180 | 69 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 183 | 20 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 187 | 52 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 194 | 22 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 206 | 8.3 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 28 | 4.1 | E | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 44 | 5.3 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 49 | 9.4 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 52 | 13 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 66 | 21 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 70 | 9.3 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 74 | 11 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 87 | 12 | E | ug/kg | |
| SD16 | 1 | Ca. scorpionfish | Liver | PCB 99 | 39 | | ug/kg | 13.3 |
| SD16 | 1 | Ca. scorpionfish | Liver | Selenium | 0.84 | | mg/kg | 0.06 |
| SD16 | 1 | Ca. scorpionfish | Liver | Total Solids | 50 | | wt% | 0.4 |
| SD16 | 1 | Ca. scorpionfish | Liver | Trans Nonachlor | 22 | | ug/kg | 20 |
| SD16 | 1 | Ca. scorpionfish | Liver | Zinc | 125 | | mg/kg | 0.58 |
| SD16 | 2 | Ca. scorpionfish | Liver | Aluminum | 5.7 | | mg/kg | 2.6 |
| SD16 | 2 | Ca. scorpionfish | Liver | Arsenic | 1.5 | | mg/kg | 1.4 |
| SD16 | 2 | Ca. scorpionfish | Liver | Cadmium | 4.37 | | mg/kg | 0.34 |
| SD16 | 2 | Ca. scorpionfish | Liver | Copper | 81.1 | | mg/kg | 0.76 |
| SD16 | 2 | Ca. scorpionfish | Liver | Hexachlorobenzene | 3.6 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | Iron | 410 | | mg/kg | 1.3 |
| SD16 | 2 | Ca. scorpionfish | Liver | Lipids | 45.4 | | wt% | 0.005 |
| SD16 | 2 | Ca. scorpionfish | Liver | Manganese | 0.85 | | mg/kg | 0.23 |
| SD16 | 2 | Ca. scorpionfish | Liver | Mercury | 0.404 | | mg/kg | 0.03 |
| SD16 | 2 | Ca. scorpionfish | Liver | p,p-DDD | 5.6 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | p,p-DDE | 340 | | ug/kg | 13.3 |
| SD16 | 2 | Ca. scorpionfish | Liver | p,p-DDT | 5.4 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 101 | 9.8 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 105 | 6.8 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 110 | 4.2 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 118 | 21 | | ug/kg | 13.3 |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 123 | 2.2 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 128 | 5.2 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 138 | 27 | | ug/kg | 13.3 |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 149 | 4.2 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 151 | 3.7 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 153/168 | 51 | | ug/kg | 13.3 |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 156 | 1.9 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 158 | 2 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 167 | 1.4 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 177 | 2.8 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 180 | 23 | | ug/kg | 13.3 |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 183 | 6.2 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 187 | 20 | | ug/kg | 13.3 |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 194 | 6 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 206 | 4.6 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 66 | 2.6 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 87 | 2.4 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | PCB 99 | 11 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | Selenium | 0.906 | | mg/kg | 0.06 |
| SD16 | 2 | Ca. scorpionfish | Liver | Total Solids | 44 | | wt% | 0.4 |
| SD16 | 2 | Ca. scorpionfish | Liver | Trans Nonachlor | 6.8 | E | ug/kg | |
| SD16 | 2 | Ca. scorpionfish | Liver | Zinc | 166 | | mg/kg | 0.58 |
| SD16 | 3 | Ca. scorpionfish | Liver | Alpha (cis) Chlordane | 3.75 | | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD16 | 3 | Ca. scorpionfish | Liver | Aluminum | 4.8 | | mg/kg | 2.6 |
| SD16 | 3 | Ca. scorpionfish | Liver | Copper | 31.1 | | mg/kg | 0.76 |
| SD16 | 3 | Ca. scorpionfish | Liver | Hexachlorobenzene | 3.6 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | Iron | 165 | | mg/kg | 1.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | Lipids | 31.2 | | wt% | 0.005 |
| SD16 | 3 | Ca. scorpionfish | Liver | Mercury | 0.0997 | | mg/kg | 0.03 |
| SD16 | 3 | Ca. scorpionfish | Liver | o,p-DDE | 2.3 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | p,p-DDD | 13.5 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | p,p-DDE | 630 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | p,p-DDT | 8.15 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 101 | 14 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 105 | 8.3 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 110 | 8.95 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 118 | 22 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 123 | 2.7 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 128 | 5.4 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 138 | 25.5 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 149 | 7.4 | E | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 151 | 4.75 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 153/168 | 46.5 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 156 | 2.05 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 158 | 2 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 167 | 1.55 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 177 | 3.4 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 180 | 19.5 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 183 | 5.25 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 187 | 16.5 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 194 | 4.55 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 206 | 3.7 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 49 | 1.55 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 52 | 2 | | ug/kg | 13.3 |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 66 | 5.1 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 70 | 2.35 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 74 | 2.35 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 87 | 3.6 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | PCB 99 | 12 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | Selenium | 0.864 | | mg/kg | 0.06 |
| SD16 | 3 | Ca. scorpionfish | Liver | Total Solids | 44.3 | | wt% | 0.4 |
| SD16 | 3 | Ca. scorpionfish | Liver | Trans Nonachlor | 11.5 | | ug/kg | |
| SD16 | 3 | Ca. scorpionfish | Liver | Zinc | 97.7 | | mg/kg | 0.58 |
| SD17 | 1 | Ca. scorpionfish | Liver | Aluminum | 34.1 | | mg/kg | 2.6 |
| SD17 | 1 | Ca. scorpionfish | Liver | Cadmium | 1.76 | | mg/kg | 0.34 |
| SD17 | 1 | Ca. scorpionfish | Liver | Copper | 29.3 | | mg/kg | 0.76 |
| SD17 | 1 | Ca. scorpionfish | Liver | Hexachlorobenzene | 2.1 | E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | Iron | 147 | | mg/kg | 1.3 |
| SD17 | 1 | Ca. scorpionfish | Liver | Lipids | 32.7 | | wt% | 0.005 |
| SD17 | 1 | Ca. scorpionfish | Liver | Manganese | 0.33 | | mg/kg | 0.23 |
| SD17 | 1 | Ca. scorpionfish | Liver | Mercury | 0.138 | | mg/kg | 0.03 |
| SD17 | 1 | Ca. scorpionfish | Liver | o,p-DDE | 1.8 | E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | p,p-DDD | 8.6 | E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | p,p-DDE | 390 | | ug/kg | 13.3 |

| Station | Rep | Species | Tissue | Parameter | Value | Units | MDL |
|---|---|---|---|---|---|---|---|
| SD17 | 1 | Ca. scorpionfish | Liver | p,p-DDT | 4.6 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 101 | 6.3 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 105 | 4.6 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 110 | 4 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 118 | 13 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 123 | 1.2 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 128 | 3.4 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 138 | 15 | ug/kg | 13.3 |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 149 | 4.6 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 151 | 2.5 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 153/168 | 24 | ug/kg | 13.3 |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 158 | 1.4 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 177 | 1.9 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 180 | 14 | ug/kg | 13.3 |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 183 | 3.3 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 187 | 9.4 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 194 | 3.1 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 206 | 3.1 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 66 | 2.7 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 74 | 1.3 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 87 | 1.7 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | PCB 99 | 5.7 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | Selenium | 0.654 | mg/kg | 0.06 |
| SD17 | 1 | Ca. scorpionfish | Liver | Total Solids | 56.9 | wt% | 0.4 |
| SD17 | 1 | Ca. scorpionfish | Liver | Trans Nonachlor | 6.3 E | ug/kg | |
| SD17 | 1 | Ca. scorpionfish | Liver | Zinc | 114 | mg/kg | 0.58 |
| SD17 | 2 | Ca. scorpionfish | Liver | Alpha (cis) Chlordane | 3.3 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | Aluminum | 11.6 | mg/kg | 2.6 |
| SD17 | 2 | Ca. scorpionfish | Liver | Cadmium | 3.33 | mg/kg | 0.34 |
| SD17 | 2 | Ca. scorpionfish | Liver | Copper | 31.6 | mg/kg | 0.76 |
| SD17 | 2 | Ca. scorpionfish | Liver | Hexachlorobenzene | 2.4 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | Iron | 206 | mg/kg | 1.3 |
| SD17 | 2 | Ca. scorpionfish | Liver | Lipids | 30.7 | wt% | 0.005 |
| SD17 | 2 | Ca. scorpionfish | Liver | Manganese | 0.43 | mg/kg | 0.23 |
| SD17 | 2 | Ca. scorpionfish | Liver | Mercury | 0.304 | mg/kg | 0.03 |
| SD17 | 2 | Ca. scorpionfish | Liver | p,p-DDD | 8.4 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | p,p-DDE | 540 | ug/kg | 13.3 |
| SD17 | 2 | Ca. scorpionfish | Liver | p,p-DDT | 5.4 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 101 | 8.4 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 105 | 6.6 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 110 | 5.1 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 118 | 19 | ug/kg | 13.3 |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 123 | 2 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 128 | 5.6 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 138 | 26 | ug/kg | 13.3 |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 149 | 4.6 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 151 | 5 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 153/168 | 49 | ug/kg | 13.3 |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 156 | 3.2 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 158 | 1.8 E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 167 | 1.9 E | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 177 | 4.8 | E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 180 | 30 | | ug/kg | 13.3 |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 183 | 6.9 | E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 187 | 21 | | ug/kg | 13.3 |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 194 | 7.2 | E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 206 | 4.9 | E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 66 | 3 | E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 87 | 2 | E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | PCB 99 | 8.1 | E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | Selenium | 0.83 | | mg/kg | 0.06 |
| SD17 | 2 | Ca. scorpionfish | Liver | Total Solids | 50.9 | | wt% | 0.4 |
| SD17 | 2 | Ca. scorpionfish | Liver | Trans Nonachlor | 9.3 | E | ug/kg | |
| SD17 | 2 | Ca. scorpionfish | Liver | Zinc | 107 | | mg/kg | 0.58 |
| SD17 | 3 | Ca. scorpionfish | Liver | Aluminum | 6 | | mg/kg | 2.6 |
| SD17 | 3 | Ca. scorpionfish | Liver | Cadmium | 4.09 | | mg/kg | 0.34 |
| SD17 | 3 | Ca. scorpionfish | Liver | Copper | 50.5 | | mg/kg | 0.76 |
| SD17 | 3 | Ca. scorpionfish | Liver | Hexachlorobenzene | 2.6 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | Iron | 193 | | mg/kg | 1.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | Lipids | 23.6 | | wt% | 0.005 |
| SD17 | 3 | Ca. scorpionfish | Liver | p,p-DDD | 5.5 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | p,p-DDE | 290 | | ug/kg | 13.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | p,p-DDT | 3.5 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 101 | 7.2 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 105 | 5 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 110 | 3.9 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 118 | 12 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 123 | 2.2 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 128 | 4.3 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 138 | 16 | | ug/kg | 13.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 149 | 4.5 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 151 | 3.3 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 153/168 | 28 | | ug/kg | 13.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 156 | 2.8 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 157 | 2.3 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 158 | 1.9 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 167 | 2.1 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 177 | 3 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 180 | 18 | | ug/kg | 13.3 |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 183 | 4 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 187 | 13 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 194 | 5.1 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 206 | 4.6 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 66 | 2.8 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 74 | 1.7 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 87 | 1.8 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | PCB 99 | 6.6 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | Selenium | 0.934 | | mg/kg | 0.06 |
| SD17 | 3 | Ca. scorpionfish | Liver | Total Solids | 38.1 | | wt% | 0.4 |
| SD17 | 3 | Ca. scorpionfish | Liver | Trans Nonachlor | 6.4 | E | ug/kg | |
| SD17 | 3 | Ca. scorpionfish | Liver | Zinc | 153 | | mg/kg | 0.58 |
| SD18 | 1 | Hornyhead turbot | Liver | Arsenic | 4.5 | | mg/kg | 1.4 |

| Station | Rep | Species | Tissue | Parameter | Value | Units | MDL |
|---|---|---|---|---|---|---|---|
| SD18 | 1 | Hornyhead turbot | Liver | Cadmium | 9.56 | mg/kg | 0.34 |
| SD18 | 1 | Hornyhead turbot | Liver | Copper | 10.8 | mg/kg | 0.76 |
| SD18 | 1 | Hornyhead turbot | Liver | Iron | 57.1 | mg/kg | 1.3 |
| SD18 | 1 | Hornyhead turbot | Liver | Lipids | 13.8 | wt% | 0.005 |
| SD18 | 1 | Hornyhead turbot | Liver | Manganese | 0.8 | mg/kg | 0.23 |
| SD18 | 1 | Hornyhead turbot | Liver | Mercury | 0.172 | mg/kg | 0.03 |
| SD18 | 1 | Hornyhead turbot | Liver | p,p-DDD | 2 E | ug/kg | |
| SD18 | 1 | Hornyhead turbot | Liver | p,p-DDE | 92 | ug/kg | 13.3 |
| SD18 | 1 | Hornyhead turbot | Liver | PCB 118 | 2.3 E | ug/kg | |
| SD18 | 1 | Hornyhead turbot | Liver | PCB 138 | 4.1 E | ug/kg | |
| SD18 | 1 | Hornyhead turbot | Liver | PCB 153/168 | 7.6 E | ug/kg | |
| SD18 | 1 | Hornyhead turbot | Liver | PCB 180 | 6.6 E | ug/kg | |
| SD18 | 1 | Hornyhead turbot | Liver | PCB 187 | 3.1 E | ug/kg | |
| SD18 | 1 | Hornyhead turbot | Liver | PCB 194 | 2 E | ug/kg | |
| SD18 | 1 | Hornyhead turbot | Liver | PCB 206 | 4.5 E | ug/kg | |
| SD18 | 1 | Hornyhead turbot | Liver | PCB 66 | 2.3 E | ug/kg | |
| SD18 | 1 | Hornyhead turbot | Liver | Selenium | 0.609 | mg/kg | 0.06 |
| SD18 | 1 | Hornyhead turbot | Liver | Total Solids | 26.6 | wt% | 0.4 |
| SD18 | 1 | Hornyhead turbot | Liver | Zinc | 83.1 | mg/kg | 0.58 |
| SD18 | 2 | Hornyhead turbot | Liver | Aluminum | 27.8 | mg/kg | 2.6 |
| SD18 | 2 | Hornyhead turbot | Liver | Arsenic | 11.6 | mg/kg | 1.4 |
| SD18 | 2 | Hornyhead turbot | Liver | Cadmium | 6.23 | mg/kg | 0.34 |
| SD18 | 2 | Hornyhead turbot | Liver | Copper | 5.13 | mg/kg | 0.76 |
| SD18 | 2 | Hornyhead turbot | Liver | Hexachlorobenzene | 1.4 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | Iron | 73.7 | mg/kg | 1.3 |
| SD18 | 2 | Hornyhead turbot | Liver | Lipids | 6.78 | wt% | 0.005 |
| SD18 | 2 | Hornyhead turbot | Liver | Manganese | 0.65 | mg/kg | 0.23 |
| SD18 | 2 | Hornyhead turbot | Liver | Mercury | 0.17 | mg/kg | 0.03 |
| SD18 | 2 | Hornyhead turbot | Liver | o,p-DDE | 3.2 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | p,p-DDD | 7.7 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | p,p-DDE | 370 | ug/kg | 13.3 |
| SD18 | 2 | Hornyhead turbot | Liver | p,p-DDT | 5.5 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 101 | 5.6 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 105 | 2.5 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 118 | 9.9 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 128 | 2.8 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 138 | 19 | ug/kg | 13.3 |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 149 | 3.5 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 151 | 1.9 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 153/168 | 35 | ug/kg | 13.3 |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 158 | 1.9 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 180 | 27 | ug/kg | 13.3 |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 183 | 7.3 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 187 | 15 | ug/kg | 13.3 |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 194 | 6.4 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 206 | 7.4 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | PCB 99 | 7.5 E | ug/kg | |
| SD18 | 2 | Hornyhead turbot | Liver | Selenium | 0.826 | mg/kg | 0.06 |
| SD18 | 2 | Hornyhead turbot | Liver | Tin | 88.2 | mg/kg | 4.6 |
| SD18 | 2 | Hornyhead turbot | Liver | Total Solids | 31.3 | wt% | 0.4 |
| SD18 | 2 | Hornyhead turbot | Liver | Zinc | 67.4 | mg/kg | 0.58 |

| Station | Rep | Species | Tissue | Parameter | Value | Units | MDL |
|---|---|---|---|---|---|---|---|
| SD19 | 1 | Hornyhead turbot | Liver | Aluminum | 10.4 | mg/kg | 2.6 |
| SD19 | 1 | Hornyhead turbot | Liver | Arsenic | 2.9 | mg/kg | 1.4 |
| SD19 | 1 | Hornyhead turbot | Liver | Cadmium | 4.19 | mg/kg | 0.34 |
| SD19 | 1 | Hornyhead turbot | Liver | Copper | 8.18 | mg/kg | 0.76 |
| SD19 | 1 | Hornyhead turbot | Liver | Hexachlorobenzene | 1 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | Iron | 48 | mg/kg | 1.3 |
| SD19 | 1 | Hornyhead turbot | Liver | Lipids | 9.1 | wt% | 0.005 |
| SD19 | 1 | Hornyhead turbot | Liver | Mercury | 0.0897 | mg/kg | 0.03 |
| SD19 | 1 | Hornyhead turbot | Liver | p,p-DDD | 2.5 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | p,p-DDE | 80 | ug/kg | 13.3 |
| SD19 | 1 | Hornyhead turbot | Liver | PCB 101 | 2.5 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | PCB 118 | 3.4 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | PCB 138 | 5.8 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | PCB 153/168 | 9.3 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | PCB 180 | 5.7 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | PCB 187 | 4.4 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | PCB 194 | 1.7 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | PCB 206 | 3.7 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | PCB 28 | 2.2 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | PCB 99 | 2.3 E | ug/kg | |
| SD19 | 1 | Hornyhead turbot | Liver | Selenium | 0.891 | mg/kg | 0.06 |
| SD19 | 1 | Hornyhead turbot | Liver | Total Solids | 26.7 | wt% | 0.4 |
| SD19 | 1 | Hornyhead turbot | Liver | Zinc | 49.8 | mg/kg | 0.58 |
| SD19 | 2 | Ca. scorpionfish | Liver | Aluminum | 11 | mg/kg | 2.6 |
| SD19 | 2 | Ca. scorpionfish | Liver | Copper | 44.4 | mg/kg | 0.76 |
| SD19 | 2 | Ca. scorpionfish | Liver | Hexachlorobenzene | 2.7 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | Iron | 147 | mg/kg | 1.3 |
| SD19 | 2 | Ca. scorpionfish | Liver | Lipids | 22.5 | wt% | 0.005 |
| SD19 | 2 | Ca. scorpionfish | Liver | Mercury | 0.108 | mg/kg | 0.03 |
| SD19 | 2 | Ca. scorpionfish | Liver | p,p-DDD | 6 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | p,p-DDE | 250 | ug/kg | 13.3 |
| SD19 | 2 | Ca. scorpionfish | Liver | p,p-DDT | 4.8 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 101 | 6.3 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 105 | 3.6 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 110 | 3.1 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 118 | 10 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 128 | 3 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 138 | 15 | ug/kg | 13.3 |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 149 | 4 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 151 | 3.1 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 153/168 | 28 | ug/kg | 13.3 |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 158 | 1.1 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 177 | 2.1 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 180 | 13 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 183 | 4.4 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 187 | 16 | ug/kg | 13.3 |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 194 | 5 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 206 | 5.6 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 52 | 2.6 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | PCB 99 | 6 E | ug/kg | |
| SD19 | 2 | Ca. scorpionfish | Liver | Selenium | 0.635 | mg/kg | 0.06 |

| Station | Rep | Species | Tissue | Parameter | Value | Units | MDL |
|---|---|---|---|---|---|---|---|
| SD19 | 2 | Ca. scorpionfish | Liver | Total Solids | 45.7 | wt% | 0.4 |
| SD19 | 2 | Ca. scorpionfish | Liver | Zinc | 105 | mg/kg | 0.58 |
| SD20 | 1 | Hornyhead turbot | Liver | Aluminum | 8.4 | mg/kg | 2.6 |
| SD20 | 1 | Hornyhead turbot | Liver | Arsenic | 2.5 | mg/kg | 1.4 |
| SD20 | 1 | Hornyhead turbot | Liver | Cadmium | 5.49 | mg/kg | 0.34 |
| SD20 | 1 | Hornyhead turbot | Liver | Copper | 6.82 | mg/kg | 0.76 |
| SD20 | 1 | Hornyhead turbot | Liver | Hexachlorobenzene | 1.5 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | Iron | 53.1 | mg/kg | 1.3 |
| SD20 | 1 | Hornyhead turbot | Liver | Lipids | 11.1 | wt% | 0.005 |
| SD20 | 1 | Hornyhead turbot | Liver | Manganese | 0.72 | mg/kg | 0.23 |
| SD20 | 1 | Hornyhead turbot | Liver | Mercury | 0.149 | mg/kg | 0.03 |
| SD20 | 1 | Hornyhead turbot | Liver | o,p-DDE | 1.6 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | p,p-DDD | 3.7 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | p,p-DDE | 110 | ug/kg | 13.3 |
| SD20 | 1 | Hornyhead turbot | Liver | p,p-DDT | 2.5 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | PCB 101 | 2.6 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | PCB 118 | 3.5 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | PCB 138 | 6.7 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | PCB 153/168 | 11 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | PCB 180 | 8.2 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | PCB 183 | 1.6 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | PCB 187 | 5.3 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | PCB 194 | 2.1 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | PCB 206 | 4.3 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | PCB 99 | 3 E | ug/kg | |
| SD20 | 1 | Hornyhead turbot | Liver | Selenium | 0.75 | mg/kg | 0.06 |
| SD20 | 1 | Hornyhead turbot | Liver | Total Solids | 28.1 | wt% | 0.4 |
| SD20 | 1 | Hornyhead turbot | Liver | Zinc | 56.5 | mg/kg | 0.58 |
| SD20 | 2 | Longfin sanddab | Liver | Aluminum | 17 | mg/kg | 2.6 |
| SD20 | 2 | Longfin sanddab | Liver | Arsenic | 1.4 | mg/kg | 1.4 |
| SD20 | 2 | Longfin sanddab | Liver | Cadmium | 2.06 | mg/kg | 0.34 |
| SD20 | 2 | Longfin sanddab | Liver | Copper | 8.01 | mg/kg | 0.76 |
| SD20 | 2 | Longfin sanddab | Liver | Hexachlorobenzene | 3.2 E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | Iron | 111 | mg/kg | 1.3 |
| SD20 | 2 | Longfin sanddab | Liver | Lipids | 43.2 | wt% | 0.005 |
| SD20 | 2 | Longfin sanddab | Liver | Manganese | 0.57 | mg/kg | 0.23 |
| SD20 | 2 | Longfin sanddab | Liver | Mercury | 0.0701 | mg/kg | 0.03 |
| SD20 | 2 | Longfin sanddab | Liver | o,p-DDE | 5.4 E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | p,p-DDD | 9.2 E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | p,p-DDE | 490 | ug/kg | 13.3 |
| SD20 | 2 | Longfin sanddab | Liver | p,p-DDT | 12 E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 101 | 7.1 E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 105 | 6.6 E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 110 | 2.9 E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 118 | 22 | ug/kg | 13.3 |
| SD20 | 2 | Longfin sanddab | Liver | PCB 123 | 2.6 E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 128 | 7.7 E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 138 | 36 | ug/kg | 13.3 |
| SD20 | 2 | Longfin sanddab | Liver | PCB 149 | 7.2 E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 151 | 4.7 E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 153/168 | 59 | ug/kg | 13.3 |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD20 | 2 | Longfin sanddab | Liver | PCB 156 | 3.2 | E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 158 | 2.4 | E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 167 | 2.2 | E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 177 | 5.8 | E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 180 | 32 | | ug/kg | 13.3 |
| SD20 | 2 | Longfin sanddab | Liver | PCB 183 | 8.6 | E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 187 | 27 | | ug/kg | 13.3 |
| SD20 | 2 | Longfin sanddab | Liver | PCB 194 | 8.8 | E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 206 | 4.7 | E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 66 | 2.7 | E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | PCB 99 | 12 | E | ug/kg | |
| SD20 | 2 | Longfin sanddab | Liver | Selenium | 0.747 | | mg/kg | 0.06 |
| SD20 | 2 | Longfin sanddab | Liver | Total Solids | 57 | | wt% | 0.4 |
| SD20 | 2 | Longfin sanddab | Liver | Zinc | 25.9 | | mg/kg | 0.58 |
| SD20 | 3 | Ca. scorpionfish | Liver | Aluminum | 37.4 | | mg/kg | 2.6 |
| SD20 | 3 | Ca. scorpionfish | Liver | Arsenic | 1.5 | | mg/kg | 1.4 |
| SD20 | 3 | Ca. scorpionfish | Liver | Cadmium | 0.37 | | mg/kg | 0.34 |
| SD20 | 3 | Ca. scorpionfish | Liver | Copper | 33.1 | | mg/kg | 0.76 |
| SD20 | 3 | Ca. scorpionfish | Liver | Hexachlorobenzene | 3 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | Iron | 199 | | mg/kg | 1.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | Lipids | 31.2 | | wt% | 0.005 |
| SD20 | 3 | Ca. scorpionfish | Liver | Mercury | 0.0999 | | mg/kg | 0.03 |
| SD20 | 3 | Ca. scorpionfish | Liver | p,p-DDD | 7.3 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | p,p-DDE | 450 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | p,p-DDT | 5.2 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 101 | 8.9 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 105 | 6.7 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 110 | 4.5 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 118 | 19 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 123 | 2.1 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 128 | 6.8 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 138 | 30 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 149 | 3.5 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 151 | 5.1 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 153/168 | 53 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 156 | 3.5 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 158 | 2.4 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 167 | 1.9 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 177 | 6.5 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 180 | 30 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 183 | 6.9 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 187 | 25 | | ug/kg | 13.3 |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 194 | 6.4 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 206 | 5 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 66 | 2.4 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 87 | 2.7 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | PCB 99 | 9.6 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | Selenium | 0.735 | | mg/kg | 0.06 |
| SD20 | 3 | Ca. scorpionfish | Liver | Total Solids | 57.4 | | wt% | 0.4 |
| SD20 | 3 | Ca. scorpionfish | Liver | Trans Nonachlor | 6.3 | E | ug/kg | |
| SD20 | 3 | Ca. scorpionfish | Liver | Zinc | 102 | | mg/kg | 0.58 |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD21 | 1 | Ca. scorpionfish | Liver | Arsenic | 2.2 | | mg/kg | 1.4 |
| SD21 | 1 | Ca. scorpionfish | Liver | Cadmium | 1.73 | | mg/kg | 0.34 |
| SD21 | 1 | Ca. scorpionfish | Liver | Copper | 23.5 | | mg/kg | 0.76 |
| SD21 | 1 | Ca. scorpionfish | Liver | Hexachlorobenzene | 4 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | Iron | 111 | | mg/kg | 1.3 |
| SD21 | 1 | Ca. scorpionfish | Liver | Lipids | 33.7 | | wt% | 0.005 |
| SD21 | 1 | Ca. scorpionfish | Liver | Manganese | 0.33 | | mg/kg | 0.23 |
| SD21 | 1 | Ca. scorpionfish | Liver | Mercury | 0.151 | | mg/kg | 0.03 |
| SD21 | 1 | Ca. scorpionfish | Liver | o,p-DDE | 4.3 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | p,p-DDD | 9.3 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | p,p-DDE | 530 | | ug/kg | 13.3 |
| SD21 | 1 | Ca. scorpionfish | Liver | p,p-DDT | 6.9 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 101 | 13 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 105 | 11 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 110 | 7.2 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 118 | 31 | | ug/kg | 13.3 |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 123 | 3.6 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 128 | 9.4 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 138 | 46 | | ug/kg | 13.3 |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 149 | 7.6 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 151 | 6.4 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 153/168 | 76 | | ug/kg | 13.3 |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 156 | 4.7 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 157 | 1.9 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 158 | 3.6 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 167 | 3 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 177 | 7.6 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 180 | 34 | | ug/kg | 13.3 |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 183 | 9.8 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 187 | 32 | | ug/kg | 13.3 |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 194 | 11 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 206 | 6.5 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 66 | 4.2 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 74 | 2 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 87 | 3.3 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | PCB 99 | 17 | | ug/kg | 13.3 |
| SD21 | 1 | Ca. scorpionfish | Liver | Selenium | 0.897 | | mg/kg | 0.06 |
| SD21 | 1 | Ca. scorpionfish | Liver | Total Solids | 50.1 | | wt% | 0.4 |
| SD21 | 1 | Ca. scorpionfish | Liver | Trans Nonachlor | 8.3 | E | ug/kg | |
| SD21 | 1 | Ca. scorpionfish | Liver | Zinc | 77.6 | | mg/kg | 0.58 |
| SD21 | 2 | Longfin sanddab | Liver | Arsenic | 4.6 | | mg/kg | 1.4 |
| SD21 | 2 | Longfin sanddab | Liver | Cadmium | 0.59 | | mg/kg | 0.34 |
| SD21 | 2 | Longfin sanddab | Liver | Copper | 11.3 | | mg/kg | 0.76 |
| SD21 | 2 | Longfin sanddab | Liver | Hexachlorobenzene | 3.4 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | Iron | 38.7 | | mg/kg | 1.3 |
| SD21 | 2 | Longfin sanddab | Liver | Lipids | 42.7 | | wt% | 0.005 |
| SD21 | 2 | Longfin sanddab | Liver | Manganese | 0.34 | | mg/kg | 0.23 |
| SD21 | 2 | Longfin sanddab | Liver | Mercury | 0.0914 | | mg/kg | 0.03 |
| SD21 | 2 | Longfin sanddab | Liver | o,p-DDE | 6 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | p,p-DDD | 10 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | p,p-DDE | 510 | | ug/kg | 13.3 |

| Station | Rep | Species | Tissue | Parameter | Value | | Units | MDL |
|---|---|---|---|---|---|---|---|---|
| SD21 | 2 | Longfin sanddab | Liver | p,p-DDT | 16 | | ug/kg | 13.3 |
| SD21 | 2 | Longfin sanddab | Liver | PCB 101 | 6.8 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 105 | 7.3 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 110 | 3.5 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 118 | 22 | | ug/kg | 13.3 |
| SD21 | 2 | Longfin sanddab | Liver | PCB 123 | 2.2 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 128 | 8 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 138 | 40 | | ug/kg | 13.3 |
| SD21 | 2 | Longfin sanddab | Liver | PCB 149 | 8.5 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 151 | 5.5 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 153/168 | 63 | | ug/kg | 13.3 |
| SD21 | 2 | Longfin sanddab | Liver | PCB 156 | 2.9 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 158 | 2.8 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 167 | 2.3 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 170 | 15 | | ug/kg | 13.3 |
| SD21 | 2 | Longfin sanddab | Liver | PCB 177 | 6 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 180 | 30 | | ug/kg | 13.3 |
| SD21 | 2 | Longfin sanddab | Liver | PCB 183 | 9 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 187 | 30 | | ug/kg | 13.3 |
| SD21 | 2 | Longfin sanddab | Liver | PCB 194 | 10 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 206 | 5.5 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 66 | 3.5 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 74 | 2.2 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | PCB 99 | 15 | | ug/kg | 13.3 |
| SD21 | 2 | Longfin sanddab | Liver | Selenium | 1.06 | | mg/kg | 0.06 |
| SD21 | 2 | Longfin sanddab | Liver | Total Solids | 56.4 | | wt% | 0.4 |
| SD21 | 2 | Longfin sanddab | Liver | Trans Nonachlor | 4.3 | E | ug/kg | |
| SD21 | 2 | Longfin sanddab | Liver | Zinc | 15.8 | | mg/kg | 0.58 |
| SD21 | 3 | Ca. scorpionfish | Liver | Cadmium | 0.515 | | mg/kg | 0.34 |
| SD21 | 3 | Ca. scorpionfish | Liver | Copper | 18.7 | | mg/kg | 0.76 |
| SD21 | 3 | Ca. scorpionfish | Liver | Hexachlorobenzene | 2.4 | | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | Iron | 84.1 | | mg/kg | 1.3 |
| SD21 | 3 | Ca. scorpionfish | Liver | Lipids | 25.6 | | wt% | 0.005 |
| SD21 | 3 | Ca. scorpionfish | Liver | Mercury | 0.157 | | mg/kg | 0.03 |
| SD21 | 3 | Ca. scorpionfish | Liver | o,p-DDE | 3 | | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | p,p-DDD | 10 | E | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | p,p-DDE | 460 | | ug/kg | 13.3 |
| SD21 | 3 | Ca. scorpionfish | Liver | p,p-DDT | 6.45 | | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 101 | 11 | E | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 105 | 6.8 | | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 110 | 6.2 | | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 118 | 19.5 | | ug/kg | 13.3 |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 123 | 2.4 | | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 128 | 4.9 | | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 138 | 22.5 | | ug/kg | 13.3 |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 149 | 5.45 | | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 151 | 3.95 | | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 153/168 | 40 | | ug/kg | 13.3 |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 156 | 2.5 | | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 158 | 1.9 | | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 167 | 1.65 | | ug/kg | |

| Station | Rep | Species | Tissue | Parameter | Value | Units | MDL |
|---|---|---|---|---|---|---|---|
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 177 | 3.05 | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 180 | 18.5 | ug/kg | 13.3 |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 183 | 4.9 | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 187 | 14.5 | ug/kg | 13.3 |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 194 | 5.25 | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 206 | 4 | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 66 | 3.6 | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 70 | 2 | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 74 | 0.95 | ug/kg | 13.3 |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 87 | 2.55 | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | PCB 99 | 9.35 | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | Selenium | 0.808 | mg/kg | 0.06 |
| SD21 | 3 | Ca. scorpionfish | Liver | Total Solids | 47.8 | wt% | 0.4 |
| SD21 | 3 | Ca. scorpionfish | Liver | Trans Nonachlor | 8.25 | ug/kg | |
| SD21 | 3 | Ca. scorpionfish | Liver | Zinc | 64 | mg/kg | 0.58 |

## Appendix D

## Random Sample Survey for the San Diego Region (July 2002)

## Sediment Quality

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# Appendix D

# July 2002 Regional Survey off San Diego

# Sediment Quality

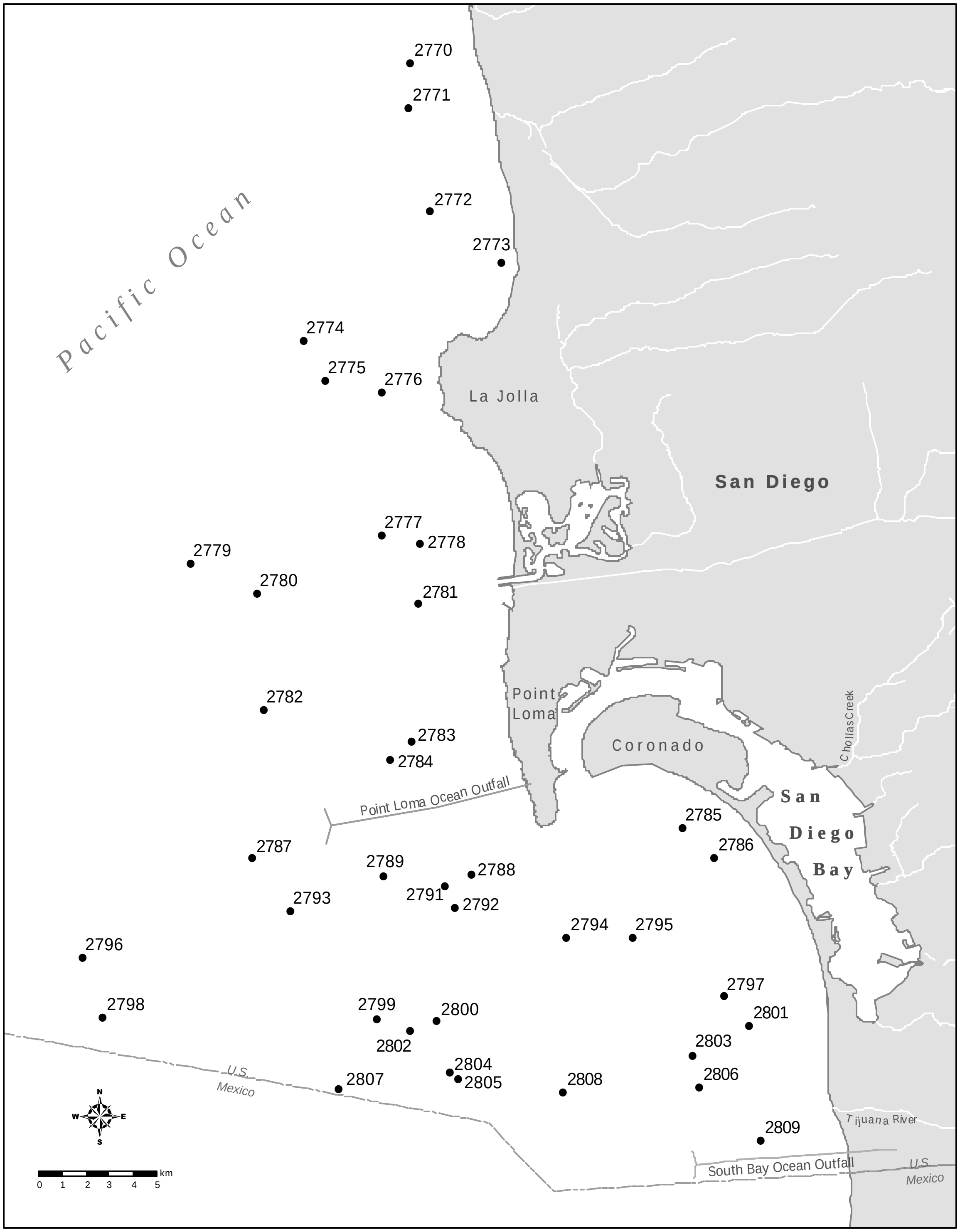
## INTRODUCTION

The City of San Diego has conducted summer surveys of sediment conditions throughout the San Diego region from 1994 through 2002 in order to evaluate patterns and trends over a large geographic area. Such region-wide monitoring is designed not only to assess the quality and characteristics of sediments, but to provide additional information that may help to identify and distinguish reference areas from sites impacted by wastewater discharge, stormwater inputs and other sources of contamination. These annual surveys are based on an array of stations randomly selected each year by the United States Environmental Protection Agency (USEPA) using the USEPA probability-based EMAP design. The 1994 and 1998 surveys off San Diego were conducted as part of the 1994 Southern California Bight Pilot Project (SCBPP) and the 1998 Southern California Bight Monitoring Survey (Bight'98). These large-scale surveys included other major southern California dischargers, and included sampling sites representing the entire Southern California Bight (i.e., Cabo Colnett, Mexico to Point Conception, U.S.A.). The same randomized sampling design was used in the surveys limited to the San Diego region (1995-1997 and 1999-2002).

This appendix presents summaries the analyses of sediment particle size and chemistry data collected during the San Diego regional survey of 2002.

## MATERIALS & METHODS

The July 2002 survey of randomly selected sites off San Diego covered an area from Del Mar south to the United States/Mexico border (Figure D.1). This survey, along with previous regional surveys, used the USEPA probability-based EMAP sampling design in which a hexagonal grid was randomly placed over a map of the region (Bight'98 Steering Committee 1998). One sample site was then randomly selected from within each grid cell. This randomization helps to ensure an unbiased estimate of ecological condition. The area sampled included the section of the mainland shelf from nearshore to shallow slope depths (12-202 m). Although 40 sites were initially selected for the 2002 survey, only 39 were successfully sampled for benthic infauna and sediments. Sampling at one site was unsuccessful due to the presence of a rocky reef, which made it impossible to collect samples.




# Figure D.1

Randomly selected regional sediment quality stations sampled off San Diego, CA (July 2002).

Benthic sediment samples were collected using a modified 0.1-$m^2$ chain-rigged van Veen grab. Sub-samples were taken from the top 2 cm of the sediment surface and handled according to EPA guidelines (USEPA 1987). All sediment analyses were performed at the City of San Diego Wastewater Chemistry Laboratory. Particle size analyses were performed using a Horiba LA-900 laser analyzer, which measures particles ranging in size from 0 to 10 phi (i.e., sand, silt and clay fractions). Sand was defined as particles ranging in size from >0 to 4 phi, silt as particles from >4 to 8.0 phi, and clay as particles >8.0 phi. The fraction of coarser sediments (e.g., very coarse sand, gravel, shell hash) in each sample was determined by measuring the weight of particles retained on a 1.0 mm mesh sieve (i.e., ≤0 phi), and expressed as the percent weight of the total sample sieved. This coarse fraction is represented as "Coarse" in Table D.1. Sediment particle size parameters were summarized according to calculations based on a normal probability scale (see Folk 1968). These include: median and mean phi size, sorting coefficient (standard deviation), skewness, kurtosis and percent sediment type (i.e., coarse particles, sand, silt, clay).

The following sediment chemical parameters were analyzed: total organic carbon (TOC), total nitrogen, total sulfides, trace metals, chlorinated pesticides, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyl compounds (PCBs). These data were generally limited to values above method detection limits (MDLs). Some parameters were determined to be present in a sample with high confidence (i.e., peaks are confirmed by mass-spectrometry, MS), but at levels below the MDL. These were included in the data as estimated values. Null (i.e., zero) values represent instances where the substance was either not detected or detected below the MDL and not confirmed by MS. Values for metals, TOC, TN and pesticides (i.e., p,p-DDT) were compared to median values for the Southern California Bight (SCB). Bightwide median values were determined based on the cumulative distribution function (CDF) for each parameter (see Schiff and Gossett 1998). These reference values are presented as the 50% CDF in the tables included herein.

## RESULTS

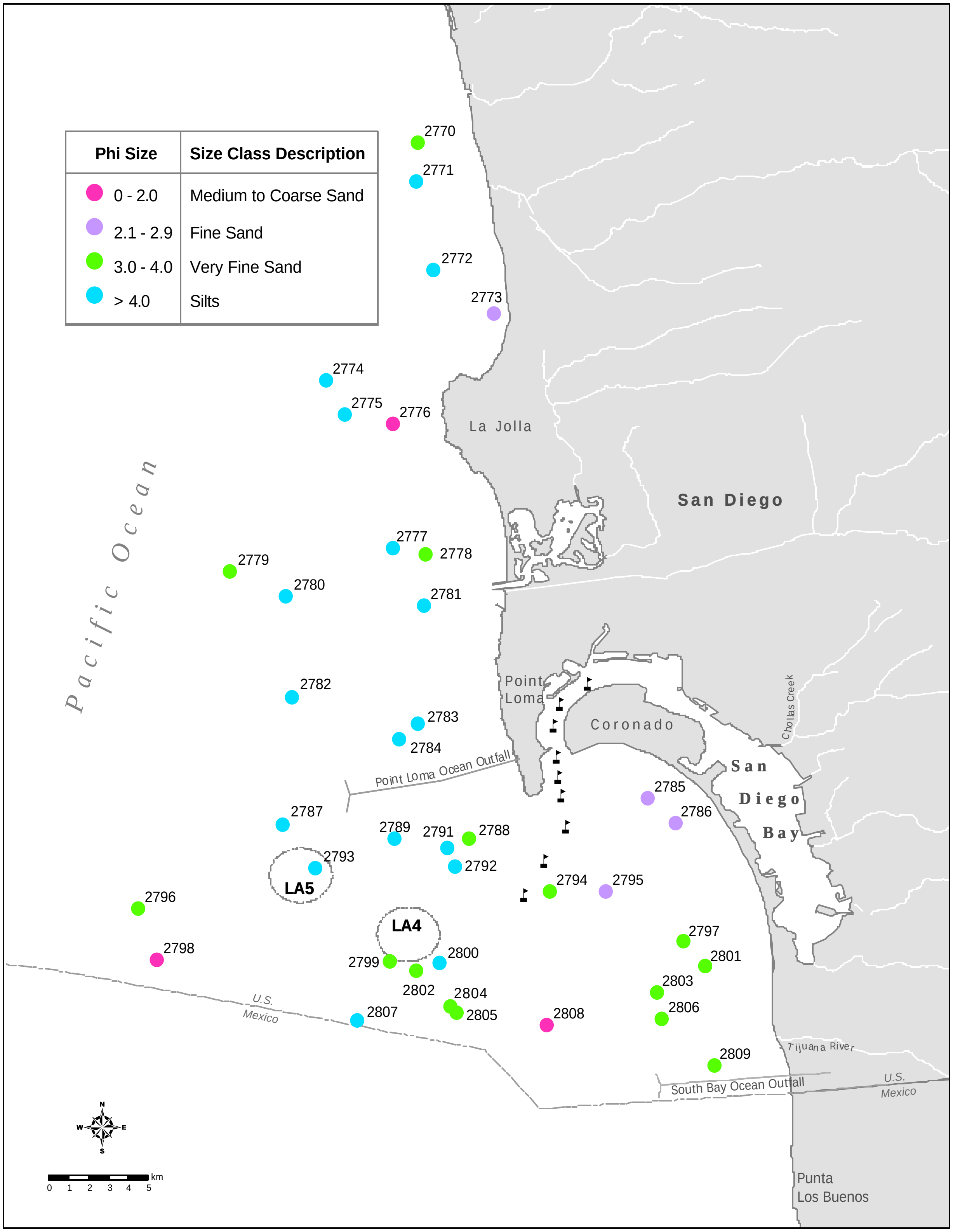
### Particle Size Analysis

With few exceptions, the overall composition of sediments off San Diego in 2002 consisted of fine sands and silts (Table D.1, Figure D.2). The general distribution of sediment particles was similar to that of the previous years: higher sand content in shallow nearshore areas, decreasing to a mixture of mostly coarse silt and fine sand at the deeper offshore sites (see City of San Diego 1999, 2000, 2001, 2002). For example, the shallow water stations (<30 m) had an average sand content of 88% with a corresponding mean phi of 2.7, while the deep water stations (≥130 m) contained 53% sand with an average mean phi of 4.1. The coarsest sediments (0.5 phi) occurred at a shallow station (2776) located near a rocky reef off Point La Jolla. These sediments consisted primarily of rock, shell hash and coarse sand. Conversely, the deepest station (2772), located near the head of La Jolla Canyon, had the finest sediments (5.4 phi) consisting primarily of silt and clay particles. Exceptions to the general pattern occurred primarily to the south of Point Loma between Coronado and the U.S.-Mexico border, and exemplify the patchy sediments in this area. The coarsest sediment sites in this area were found in deeper

## Table D.1

Summary of particle size parameters at randomly selected regional sediment stations off San Diego, CA during July 2002. Data presented includes: station; depth (m); mean phi size; standard deviation (SD); percent values for coarse fraction (Coarse), sand, silt, and clay. Data for organic indicators include total sulfides (ppm); total nitrogen (TN) (wt%); and total organic carbon (TOC) (wt%). Also included are method detection limits, area means and the 50% CDF value for the Southern California Bight where available (see Schiff and Gosset 1998). TN and TOC that exceed the 50% CDF value are indicated in bold type.

| Station | Depth (m) | Mean Phi | SD | Coarse (%) | Sand (%) | Silt (%) | Clay (%) | Sulfides ppm | TN (%) | TOC (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| **MDL** | | | | | | | | 0.1 | 0.001 | 0.009 |
| **50% CDF** | | | | | | | | | 0.051 | 0.748 |
| ***Shallow Depths*** | | | | | | | | | | |
| 2785 | 12 | 2.4 | 0.6 | 0.0 | 97.9 | 2.1 | 0.0 | 1.1 | 0.016 | 0.103 |
| 2786 | 14 | 2.7 | 0.7 | 0.0 | 92.7 | 6.8 | 0.5 | 1.8 | 0.022 | 0.152 |
| 2773 | 16 | 2.7 | 0.6 | 0.0 | 96.1 | 3.8 | 0.1 | 0.4 | 0.020 | 0.229 |
| 2801 | 18 | 3.3 | 0.6 | 0.0 | 92.7 | 6.7 | 0.6 | 0.9 | 0.012 | 0.050 |
| 2797 | 19 | 3.2 | 0.6 | 0.0 | 92.3 | 7.1 | 0.5 | 0.6 | 0.014 | 0.095 |
| 2809 | 19 | 3.2 | 0.7 | 0.0 | 89.1 | 10.1 | 0.8 | 0.8 | 0.014 | 0.096 |
| 2795 | 25 | 2.2 | 1.4 | 0.0 | 90.3 | 8.9 | 0.7 | 2.7 | 0.022 | 0.144 |
| 2803 | 25 | 3.3 | 0.7 | 0.0 | 88.0 | 11.1 | 0.9 | 0.5 | 0.013 | 0.072 |
| 2806 | 26 | 3.4 | 0.7 | 0.0 | 85.7 | 13.4 | 0.9 | 2.3 | 0.018 | 0.132 |
| 2776 | 29 | 0.5 | 0.9 | 40.2 | 59.8 | 0.0 | 0.0 | 0.0 | 0.022 | 0.221 |
| 2794 | 29 | 3.1 | 0.9 | 0.0 | 87.1 | 11.6 | 1.2 | 1.7 | 0.020 | 0.132 |
| **Mean** | 21 | 2.7 | 0.8 | 3.7 | 88.3 | 7.4 | 0.6 | 1.1 | 0.018 | 0.130 |
| ***Mid-Depths*** | | | | | | | | | | |
| 2808 | 43 | 1.2 | 0.5 | 0.0 | 100.0 | 0.0 | 0.0 | 0.5 | 0.008 | 0.041 |
| 2770 | 44 | 3.9 | 1.4 | 0.0 | 63.7 | 33.1 | 3.1 | 8.0 | 0.046 | 0.386 |
| 2778 | 44 | 3.8 | 1.5 | 0.0 | 69.6 | 27.1 | 3.1 | 17.7 | 0.051 | 0.405 |
| 2781 | 48 | 3.8 | 1.4 | 0.0 | 68.6 | 28.4 | 3.0 | 7.4 | **0.053** | 0.434 |
| 2788 | 52 | 3.7 | 1.3 | 0.0 | 73.6 | 23.6 | 2.8 | 0.9 | **0.070** | 0.686 |
| 2771 | 56 | 4.1 | 2.2 | 4.4 | 52.9 | 37.5 | 5.2 | 0.5 | **0.064** | 0.537 |
| 2777 | 57 | 4.4 | 1.5 | 0.0 | 49.5 | 46.6 | 3.8 | 3.9 | **0.080** | 0.736 |
| 2775 | 59 | 4.2 | 2.6 | 8.5 | 41.8 | 41.8 | 7.9 | 3.9 | **0.084** | **0.789** |
| 2792 | 61 | 4.2 | 1.2 | 1.1 | 62.9 | 32.9 | 3.1 | 0.7 | **0.062** | 0.603 |
| 2791 | 65 | 4.3 | 1.6 | 1.1 | 51.5 | 43.4 | 4.0 | 0.9 | **0.067** | 0.703 |
| 2783 | 67 | 4.5 | 1.5 | 0.0 | 47.7 | 48.3 | 4.0 | 3.9 | **0.070** | 0.645 |
| 2805 | 73 | 3.1 | 1.2 | 0.0 | 83.9 | 14.0 | 2.2 | 0.8 | 0.038 | 0.315 |
| 2784 | 74 | 4.5 | 1.4 | 0.0 | 44.9 | 51.2 | 3.8 | 0.7 | **0.071** | 0.662 |
| 2804 | 77 | 4.0 | 1.5 | 0.0 | 68.9 | 27.4 | 3.7 | 2.9 | 0.051 | 0.454 |
| 2800 | 79 | 4.6 | 1.8 | 0.0 | 48.7 | 46.0 | 5.3 | 1.1 | **0.080** | **0.756** |
| 2789 | 84 | 4.5 | 1.5 | 0.0 | 49.8 | 45.8 | 4.4 | 0.9 | 0.049 | 0.515 |
| 2802 | 85 | 3.9 | 1.5 | 0.0 | 72.5 | 23.6 | 3.9 | 0.1 | **0.055** | 0.514 |
| 2774 | 86 | 4.6 | 1.5 | 0.0 | 45.7 | 49.7 | 4.6 | 0.5 | **0.072** | 0.652 |
| 2799 | 91 | 3.2 | 1.5 | 7.7 | 78.4 | 11.6 | 2.2 | 3.5 | 0.049 | 0.446 |
| 2780 | 94 | 4.5 | 1.6 | 0.0 | 48.1 | 47.2 | 4.7 | 1.0 | **0.068** | 0.609 |
| **Mean** | 67 | 4.0 | 1.5 | 1.1 | 61.1 | 34.0 | 3.7 | 3.0 | 0.059 | 0.54 |
| ***Deep Water*** | | | | | | | | | | |
| 2793 | 130 | 4.2 | 2.2 | 4.6 | 53.9 | 35.9 | 5.6 | 4.3 | 0.039 | 0.444 |
| 2807 | 148 | 4.3 | 1.8 | 1.7 | 56.7 | 36.6 | 5.0 | 1.9 | **0.074** | 0.664 |
| 2796 | 149 | 3.5 | 2.2 | 0.9 | 71.3 | 22.9 | 4.9 | 0.1 | 0.048 | 0.465 |
| 2779 | 150 | 4.4 | 2.4 | 5.4 | 54.0 | 33.0 | 7.5 | 2.4 | **0.060** | 0.547 |
| 2798 | 152 | 1.1 | 0.6 | 3.0 | 94.2 | 2.3 | 0.3 | 1.3 | **0.053** | **0.839** |
| 2787 | 182 | 5.0 | 1.8 | 0.0 | 34.0 | 58.7 | 7.3 | 0.9 | **0.076** | **0.812** |
| 2782 | 198 | 4.9 | 1.7 | 0.0 | 35.5 | 58.4 | 6.1 | 8.8 | **0.110** | **1.090** |
| 2772 | 202 | 5.4 | 1.7 | 0.0 | 23.0 | 69.4 | 7.6 | 134.0 | **0.142** | **1.190** |
| **Mean** | 164 | 4.1 | 1.8 | 1.9 | 52.8 | 39.7 | 5.5 | 19.2 | **0.075** | **0.756** |
| **Area Mean** | 74 | 3.6 | 1.4 | 2.0 | 67.1 | 27.6 | 3.2 | 5.8 | 0.051 | 0.471 |




## Figure D.2

Mean phi size data at randomly selected regional sediment stations off San Diego, CA (July 2002).

water along a rocky ridge located southwest of the Point Loma (e.g., station 2798), and one site off-shore of the Tijuana River (station 2808). Additionally, several shallow water sites located west of the Tijuana River (stations 2797, 2801, 2803, 2806, 2809) contained sediments that were finer than other shallow sites immediately to the north (i.e., 2785, 2786). This is probably the result of sediment deposition from the Tijuana River.

## Organic Indicators

In general, concentrations of total organic carbon (TOC), total nitrogen (TN) and sulfides were relatively low in sediment samples collected during 2002 (Table D.1). For example, over 60% of the TOC samples were less than the background levels of 0.6% (see Hendricks and Eganhouse, 1992; Zeng and Khan, 1994), and all of the samples were well below 6%, an amount present in severely impacted areas (see Zeng et al.1995). As in previous regional surveys, concentrations of TOC and TN tended to rise with increasing depth and decreasing grain size (see City of San Diego 1999, 2000, 2001, 2002). For example, mean TOC values were 0.13% at the shallow water stations and 0.76% at the deep water stations. Stations consisting primarily of silty sediments (mean phi >4.0) exceeded the median reference levels most often. The few exceptions were stations 2781, 2788, 2798 and 2802. The highest concentrations of all three organic indicators, including sulfides, occurred at a deep site (station 2772) near the head of La Jolla Canyon, a potential source of organic loading. Two mid-depth sites near the mouth of Mission Bay (stations 2778 and 2781) also had relatively high levels of sulfides, but fairly low percentages of TOC or TN.

## Trace Metals

Seven trace metals (i.e., aluminum, arsenic, chromium, iron, manganese, mercury, and zinc) were detected at almost all 39 survey stations (Table D.2). Silver, thallium and tin were undetected. The most widely distributed trace metals appeared to co-vary with iron, a pattern common among many metals found in marine sediments (see Schiff and Gossett 1998). Metal concentrations were generally higher along gradients of increasing depth, decreasing particle size, or anthropogenic inputs. This trend is similar to the general pattern of metal contamination that has been found for the Southern California Bight (Schiff and Gossett 1998).

Stations with the highest number ($\geq$3) of metals whose concentrations exceeded the median values were found near the Point Loma Ocean Outfall (pre- and post-extension discharge sites) and southward, towards the LA-4 and LA-5 dredge materials disposal sites (Figure D.3). The single exception occurred at station 2772. This deepwater site located near the head of La Jolla Canyon had the finest sediments and elevated levels of nine different metals. While many stations contained relatively high concentrations of two common trace elements (aluminum and mercury), sediments near sources of anthropogenic input contained relatively high amounts of several others, some of which are associated with industrial uses (e.g., antimony, beryllium, cadmium, lead and selenium). Some metals (e.g., copper and lead) that were found in high concentrations in San Diego Bay (City of San Diego, in prep), occurred in high concentrations almost exclusively near the LA-4/LA-5 dredge materials disposal sites (e.g., 2793, 2800, 2802). This was also true for cadmium, a metal associated with paints, plastics

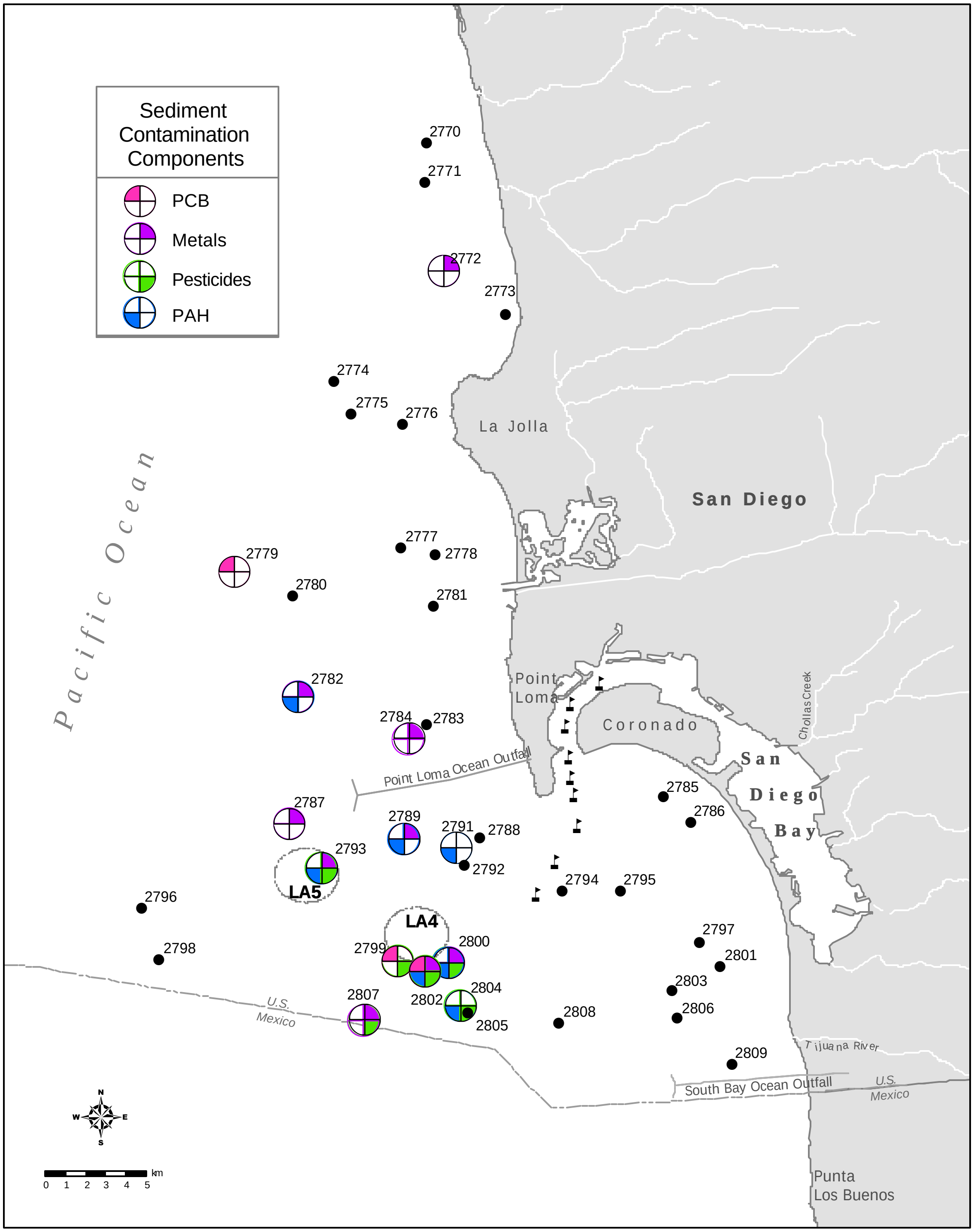
## Table D.2

Summary of metals concentrations (ppm) at randomly selected regional sediment stations off San Diego, CA during July 2002. Data for metals include: aluminum (Al); antimony (Sb); arsenic (As); Beryllium (Be); cadmium (Cd); chromium (Cr); copper (Cu); iron (Fe); lead (Pb); manganese (Mn); mercury (Hg); nickel (Ni); selenium (Se); silver (Ag); thallium (Ti), tin (Sn); and zinc (Zn). Also included are method detection limits, area means and the 50% CDF value for the Southern California Bight where available (see Schiff and Gosset 1998). Metal concentrations that exceed the 50% CDF values are indicated in bold type.

| Station | Al | Sb | As | Be | Cd | Cr | Cu | Fe | Pb |
|---|---|---|---|---|---|---|---|---|---|
| **MDL** | 5 | 5.00 | 0.08 | 0.20 | 0.5 | 3 | 2 | 3 | 5.00 |
| **50% CDF** | 9400 | 0.2 | 4.8 | 0.26 | 0.29 | 34 | 12 | 16800 | 10.2 |
| ***Shallow Depths*** | | | | | | | | | |
| 2785 | 3040 | nd | 2.05 | nd | nd | 6.4 | 3 | 4320 | nd |
| 2786 | 5350 | nd | 3.09 | **0.85** | nd | 8.3 | nd | 5970 | nd |
| 2773 | 5820 | nd | 1.49 | nd | nd | 10.0 | nd | 7150 | nd |
| 2801 | 4870 | nd | 1.32 | nd | nd | 8.6 | nd | 4720 | nd |
| 2797 | 4340 | nd | 1.58 | **1.00** | nd | nd | nd | 4100 | nd |
| 2809 | 6310 | nd | 1.54 | nd | nd | 10.3 | nd | 6430 | nd |
| 2795 | 7290 | nd | 2.62 | nd | nd | 10.6 | 3 | 7910 | nd |
| 2803 | 6380 | nd | 1.28 | **1.12** | nd | 9.9 | nd | 5680 | nd |
| 2806 | 7540 | nd | 1.69 | nd | nd | 11.0 | 6 | 6570 | nd |
| 2776 | 2500 | nd | 4.29 | nd | nd | 3.7 | nd | 6900 | nd |
| 2794 | 7230 | nd | 2.53 | nd | nd | 10.6 | 6 | 7620 | nd |
| **Mean** | 5515 | nd | 2.13 | 0.27 | nd | 8.1 | 2 | 6125 | nd |
| ***Mid-Depths*** | | | | | | | | | |
| 2808 | 1280 | nd | 2.89 | nd | nd | 8.6 | nd | 4710 | nd |
| 2770 | **12500** | nd | 3.99 | nd | nd | 18.4 | 5 | 14500 | nd |
| 2778 | 7260 | nd | 3.00 | nd | nd | 12.3 | 5 | 9200 | nd |
| 2781 | 8750 | nd | 2.89 | nd | nd | 14.2 | 5 | 10500 | nd |
| 2788 | **12200** | nd | 3.61 | nd | nd | 18.1 | 10 | 12900 | nd |
| 2771 | **12000** | nd | 3.55 | nd | nd | 20.6 | 9 | **18300** | nd |
| 2777 | **13400** | nd | 4.68 | nd | nd | 20.1 | 9 | 14600 | nd |
| 2775 | **10500** | nd | 4.49 | nd | nd | 19.8 | 8 | **18100** | 6.4 |
| 2792 | **15200** | nd | 4.28 | nd | nd | 23.4 | **13** | 16300 | nd |
| 2791 | **14200** | nd | 4.29 | nd | nd | 20.7 | 11 | 15100 | nd |
| 2783 | **14900** | nd | 4.59 | nd | nd | 22.2 | 9 | 15400 | nd |
| 2805 | 5610 | nd | 1.97 | **0.70** | nd | 8.8 | 3 | 6350 | nd |
| 2784 | **15400** | nd | 4.23 | **2.35** | nd | 21.8 | 9 | 16200 | nd |
| 2804 | 8220 | nd | 2.60 | nd | nd | 13.0 | 6 | 9030 | nd |
| 2800 | **14200** | nd | **4.81** | nd | **2.45** | 22.7 | **19** | 15400 | 5.4 |
| 2789 | **15400** | **13.6** | 4.38 | nd | nd | 24.1 | 11 | 16400 | 5.3 |
| 2802 | 9010 | nd | 2.79 | **1.12** | nd | 13.8 | **16** | 9880 | nd |
| 2774 | **13600** | nd | 3.39 | nd | nd | 19.5 | 6 | 15400 | nd |
| 2799 | 8670 | nd | 2.27 | nd | **0.76** | 14.7 | 11 | 9500 | nd |
| 2780 | **11700** | nd | 3.48 | nd | nd | 19.0 | 9 | 14100 | nd |
| **Mean** | 11200 | 13.6 | 3.61 | 1.39 | 1.61 | 17.8 | 9 | 13094 | 5.7 |
| ***Deep Water*** | | | | | | | | | |
| 2793 | **12000** | **3.3** | 2.94 | nd | nd | 20.7 | **18** | 16200 | 3.4 |
| 2807 | **12200** | nd | 2.55 | nd | **2.59** | 19.7 | 10 | 13800 | nd |
| 2796 | 4810 | nd | 3.60 | nd | nd | 19.8 | 2 | 9650 | nd |
| 2779 | 8200 | nd | 4.33 | nd | nd | 23.8 | 7 | **17600** | nd |
| 2798 | 4370 | nd | 4.05 | nd | nd | 20.0 | 3 | 10500 | nd |
| 2787 | **15700** | nd | 3.49 | nd | **0.51** | 23.9 | 12 | 16600 | nd |
| 2782 | **15600** | nd | 2.93 | nd | **0.56** | 24.1 | 12 | 15700 | nd |
| 2772 | **23100** | nd | **5.29** | nd | nd | **35.6** | **17** | **24100** | 7.5 |
| **Mean** | **11998** | **3.3** | 3.65 | nd | **1.22** | 23.5 | 10 | 15519 | 5.4 |
| **Area Mean** | 9760 | 0.4 | 3.20 | 0.18 | 0.18 | 16.2 | 7 | 11625 | 0.7 |

## Table D.2 Con't

| Station | Mn | Hg | Ni | Se | Ag | Tl | Sn | Zn |
|---|---|---|---|---|---|---|---|---|
| **MDL** | 0.5 | 0.03 | 3.0 | 0.11 | 3.0 | 10 | 12.0 | 4.0 |
| **50% CDF** | ** | 0.04 | ** | 0.29 | 0.17 | ** | ** | 56 |
| ***Shallow Depths*** | | | | | | | | |
| 2785 | 58.1 | 0.006 | nd | nd | nd | nd | nd | 8.2 |
| 2786 | 61.6 | 0.008 | nd | nd | nd | nd | nd | 14.0 |
| 2773 | 83.4 | nd | nd | nd | nd | nd | nd | 17.7 |
| 2801 | 70.2 | 0.009 | nd | nd | nd | nd | nd | 8.8 |
| 2797 | 63.6 | 0.009 | nd | nd | nd | nd | nd | 9.1 |
| 2809 | 78.7 | nd | nd | nd | nd | nd | nd | 17.5 |
| 2795 | 109.0 | 0.015 | nd | nd | nd | nd | nd | 18.3 |
| 2803 | 68.7 | 0.009 | nd | nd | nd | nd | nd | 11.2 |
| 2806 | 74.0 | nd | nd | nd | nd | nd | nd | 15.6 |
| 2776 | 31.0 | nd | nd | nd | nd | nd | nd | 5.9 |
| 2794 | 93.7 | 0.020 | nd | nd | nd | nd | nd | 17.6 |
| **Mean** | 72.0 | 0.007 | nd | nd | nd | nd | nd | 13.1 |
| ***Mid-Depths*** | | | | | | | | |
| 2808 | 12.5 | nd | nd | nd | nd | nd | nd | 18.5 |
| 2770 | 141.0 | 0.005 | nd | nd | nd | nd | nd | 31.7 |
| 2778 | 90.6 | 0.024 | nd | nd | nd | nd | nd | 22.1 |
| 2781 | 103.0 | nd | nd | nd | nd | nd | nd | 24.9 |
| 2788 | 131.0 | 0.039 | nd | nd | nd | nd | nd | 30.7 |
| 2771 | 139.0 | 0.011 | nd | nd | nd | nd | nd | 43.5 |
| 2777 | 144.0 | **0.078** | nd | nd | nd | nd | nd | 36.4 |
| 2775 | 106.0 | **0.048** | nd | 0.26 | nd | nd | nd | 37.8 |
| 2792 | 156.0 | **0.045** | 5.4 | nd | nd | nd | nd | 40.5 |
| 2791 | 138.0 | **0.041** | 4.6 | nd | nd | nd | nd | 34.8 |
| 2783 | 150.0 | **0.073** | 9.2 | nd | nd | nd | nd | 39.5 |
| 2805 | 61.0 | 0.011 | 3.0 | nd | nd | nd | nd | 14.9 |
| 2784 | 150.0 | **0.071** | 9.4 | nd | nd | nd | nd | 38.4 |
| 2804 | 80.7 | 0.021 | 5.5 | nd | nd | nd | nd | 20.9 |
| 2800 | 131.0 | **0.053** | 9.6 | nd | nd | nd | nd | 50.1 |
| 2789 | 150.0 | **0.051** | 9.5 | nd | nd | nd | nd | 36.1 |
| 2802 | 77.3 | **0.041** | 5.2 | nd | nd | nd | nd | 26.8 |
| 2774 | 135.0 | **0.040** | nd | nd | nd | nd | nd | 32.3 |
| 2799 | 79.2 | 0.038 | 5.0 | nd | nd | nd | nd | 35.3 |
| 2780 | 120.0 | **0.048** | 7.2 | 0.13 | nd | nd | nd | 30.5 |
| **Mean** | 114.8 | 0.041 | 6.7 | 0.20 | nd | nd | nd | 32.3 |
| ***Deep Water*** | | | | | | | | |
| 2793 | 106.0 | **0.053** | 2.1 | nd | nd | nd | nd | 48.3 |
| 2807 | 112.0 | nd | 9.5 | 0.29 | nd | nd | nd | 32.4 |
| 2796 | 40.9 | 0.017 | 4.2 | nd | nd | nd | nd | 16.7 |
| 2779 | 68.6 | 0.023 | nd | nd | nd | nd | nd | 35.5 |
| 2798 | 51.2 | 0.016 | 4.4 | nd | nd | nd | nd | 15.4 |
| 2787 | 129.0 | **0.045** | 12.3 | **0.38** | nd | nd | nd | 40.1 |
| 2782 | 138.0 | **0.061** | 13.3 | **0.35** | nd | nd | nd | 39.0 |
| 2772 | 209.0 | **0.097** | 16.0 | **0.55** | nd | nd | nd | **64.3** |
| **Mean** | 106.8 | 0.044 | 8.8 | 0.39 | nd | nd | nd | 36.5 |
| **Area Mean** | 101.1 | 0.029 | 3.5 | 0.05 | nd | nd | nd | 27.7 |




## Figure D.3

Distribution of various sediment contaminants at randomly selected regional sediment quality stations off San Diego, CA (July 2002). Contaminants include detected values for total-PCB, total-PAH, pesticides (total-DDT), and sites where trace metal concentrations exceeded the median value for the Southern California Bight for three or more metals.

## Table D.3

Concentrations of polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyl compounds (total PCB) and pesticides (e.g., p,p-DDT) at randomly selected regional sediment stations off San Diego (July 2002). Station values and regional means represent detected values only and are compared to MDLs and 50% CDF values for the Southern California Bight where available (see Schiff and Gosset 1998). Concentrations expressed as parts per trillion (ppt).

| Station | Total PAH | Total PCBs | Total Pesticides |
|---|---|---|---|
| **MDL** | 46 | 3100 | 11000 |
| **50% CDF** | | | 10000 |
| 2779 | nd | 820 | nd |
| 2782 | 332.2 | nd | nd |
| 2791 | 9.8 | nd | nd |
| 2793 | 71.1 | nd | 540 |
| 2799 | nd | 3000 | 450 |
| 2800 | 52.0 | nd | 1100 |
| 2802 | 24.5 | 380 | 560 |
| 2804 | 37.2 | nd | 980 |
| 2807 | nd | nd | 330 |
| **Area Mean** | 14.6 | 108 | 102 |

PAH data was unavailable for stations 2805, 2806, and 2809.

and point-source discharges. The concentrations of cadmium at stations near the disposal sites (i.e., 2800, 2807) were over five times that of stations in the vicinity of the Point Loma Ocean Outfall (i.e., 2782, 2787).

### Other Contaminants: Pesticides, PCBs and PAHs

Pesticides, polychlorinated biphenyl compounds (PCBs) and polycyclic aromatic hydrocarbons (PAHs) were detected infrequently, and in generally low concentrations during the 2002 regional survey (Table D.3). Although unrelated chemically, these contaminants were found primarily among a cluster of stations located in the vicinity the LA-4/LA-5 dredge materials disposal sites (i.e., stations 2793, 2799, 2800, 2802, 2804, 2807) and south of the Point Loma Ocean Outfall (Figure D.3). The pesticide DDT was only found in sediments around the disposal sites, while PAHs and PCBs were also detected at two more northern stations (i.e., 2782 and 2779, respectively). The presence of these contaminants at stations near the disposal sites is expected since San Diego Bay is a known source of such contamination (see Anderson et al. 1993). Previous surveys have found similar results (see City of San Diego 1999, 2000, 2001, 2002).

## DISCUSSION & SUMMARY

The distribution of sediment particles off San Diego in 2002 was similar to that of previous years and to the Southern California Bight (SCB) in general. Although the presence of canyons, peninsulas, bays, and alluvial fans from rivers contribute to the complexity of sediment particle size distribution and origin along the San Diego shelf (see Emery 1960), the general trend was for higher sand content in shallow nearshore areas and increased silt and fine sand at the deeper offshore sites. For example, stations $\leq$30 m in depth averaged 92% fine sand, while stations deeper than 130 m averaged 54% fine sand. Exceptions to this pattern occurred primarily south of Point Loma, along a deep rocky ridge located southwest of the Point Loma Ocean Outfall and in the shallow waters west of the Tijuana River. Overall, anthropogenic impacts were not apparent in sediment particle size data collected during the regional survey.

In contrast, sediment chemistries did show evidence of both natural and anthropogenic impacts in the region. Although organic indicator and trace metal concentrations were generally low, they followed the typical pattern of rising concentrations with decreasing particle size and increasing depth (see Emery 1960, Anderson et al. 1993, Schiff and Gossett 1998). The few cases of elevated organic indicator values occurred near suspected sources of organic loading (e.g., La Jolla Canyon and Mission Bay). In contrast, trace metal concentrations that exceeded median levels for the SCB occurred primarily at stations located near the LA-4/LA-5 dredge materials disposal sites and the Point Loma Ocean Outfall. Some of the naturally occurring and prevalent trace metals, such as aluminum and iron, are used in the wastewater treatment process, while others, such as copper and cadmium are most likely associated with contamination from San Diego Bay. Similarly, pesticide, PCB and PAH contamination were more common near the dredged materials disposal sites and may be related to materials removed from San Diego Bay, although levels of these contaminants remained low for the region.

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## Appendix E

## Random Sample Survey for the San Diego Region
## (July 2002)

## Benthic Infauna

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# Appendix E

# Regional Survey off San Diego (July 2002)

# Benthic Infauna

## INTRODUCTION

The City of San Diego has conducted regional benthic monitoring surveys off the coast of San Diego since 1994 (see Chapter 1). The main objectives of these surveys are: (1) to characterize the ecological health of the marine benthos for the large and diverse coastal region off San Diego; and (2) to gain a better understanding of regional conditions in order to distinguish between areas impacted by anthropogenic and natural events. These annual surveys are based on an array of stations randomly selected each year by the United States Environmental Protection Agency (USEPA) using the USEPA probability-based EMAP design. The 1994 and 1998 surveys off San Diego were conducted as part of the Southern California Bight 1994 Pilot Project (SCBPP) and the 1998 Southern California Bight Monitoring Survey (Bight'98). These large-scale surveys included other major southern California dischargers, and included sampling sites representing the entire Southern California Bight (i.e., Cabo Colnett, Mexico to Point Conception, U.S.A.). The same randomized sampling design was used in the surveys limited to the San Diego region (1995–1997 and 1999–2002).

This appendix presents an analysis and interpretation of the benthic macrofaunal data collected during the San Diego regional survey of 2002. Included are descriptions and comparisons of the region's soft-bottom macrobenthic assemblages, and analysis of benthic community structure. Results of the sediment quality analyses for this survey are provided in Appendix D of this report.

## MATERIALS & METHODS

### Collection and Processing of Benthic Samples

The July 2002 survey of randomly selected sites off San Diego covered an area from Del Mar, CA south to the United States/Mexico border (Figure E.1). This survey, along with previous regional surveys, used the USEPA probability-based EMAP sampling design in which a hexagonal grid was randomly placed over a map of the region. One sample site was then randomly selected from within each grid cell. This randomization helps to ensure an unbiased estimate of ecological condition. The area sampled included the section of the mainland shelf from nearshore to shallow slope depths (12-202 m). Although 40 sites were initially selected for the 2002 survey, sampling at one site was unsuccessful due to the presence of a rocky reef.

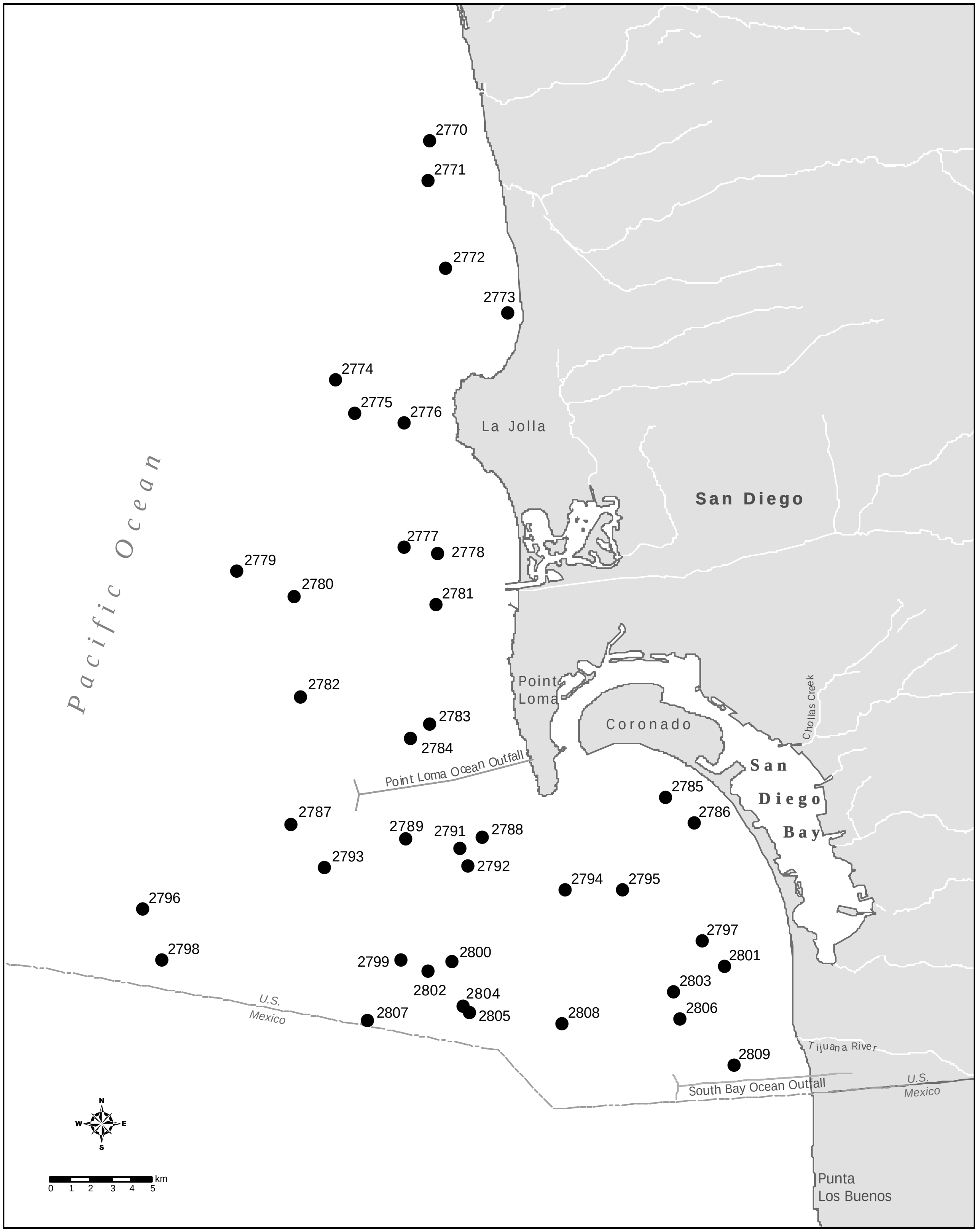



**Figure E.1**

Randomly selected regional benthic infauna stations sampled off San Diego, CA (July 2002).

Samples for benthic community analysis were collected from two replicate 0.1 $m^2$ van Veen grabs at each station. The criteria established by the USEPA to ensure consistency of grab samples were followed with regard to sample disturbance and depth of penetration (USEPA 1987). All samples were sieved aboard ship through a 1.0 mm mesh screen. Organisms retained on the screen were relaxed for 30 minutes in a magnesium sulfate solution and then fixed in buffered formalin (see City of San Diego 2003). After a minimum of 72 hours, each sample was rinsed with fresh water and transferred to 70% ethanol. All organisms were sorted from the debris into groups by a subcontractor (MEC Analytical Systems, Inc., Carlsbad, California). The biomass for each sample was measured as the wet weight in grams for each of the following major groups: Polychaetes (Annelida), Crustacea (Arthropoda), Mollusca, non-ophiuroid Echinodermata, Ophiuroidea (Echinodermata), and all other phyla combined (e.g., Cnidaria, Platyhelminthes, Phoronida, Sipuncula, etc.). Values for ophiuroids (i.e., brittle stars) were combined with those for all other echinoderms to give a total echinoderm biomass. After biomassing, all animals were identified to species or the lowest taxon possible and enumerated by City of San Diego marine biologists.

### Data Analyses

The following benthic community structure parameters were calculated for each station: (1) species richness (number of species per grab); (2) abundance (number of individuals per grab); (3) biomass (grams per grab, wet weight); (4) Shannon diversity index (H' per grab); (5) Pielou's evenness index (J' per grab); (6) Swartz dominance (number of species comprising 75% of the abundance in each grab); (7) Infaunal Trophic Index (ITI per grab) (see Word 1980); (8) Benthic Response Index (BRI per grab) (see Smith et al. 2001).

Ordination (principal coordinates) and classification (hierarchical agglomerative clustering) analyses were performed to compare the overall similarity of benthic assemblages in the region. These analyses were performed using Ecological Analysis Package (EAP) software (see Smith 1982; Smith et al. 1988). The macrofaunal abundance data were transformed by a square root and standardized by the species mean abundance values greater than zero.

## RESULTS & DISCUSSION

### Classification of Assemblages and Dominant Infauna

Ordination and classification analyses separated the sites into six major clusters based on the overall similarity of their benthic assemblages (see Figure E.2 and Table E.1). Similar to previous random sample surveys of the region, depth and sediment composition were the primary factors affecting the distribution of assemblages (e.g., City of San Diego 1999, 2000a, 2001, 2002, Bergen et al. 2001)

Cluster group A consisted of the three deepest stations, all of which occurred at depths > 180 m deep and had sediments composed of over 60% fines (Table E.1). These sites had the highest average concentrations of

## Table E.1

Sediment composition, organic content and dominant taxa (by abundance and frequency of occurrence) for the major station groups derived from cluster analysis of macrofaunal abundance data for the July 2002 survey of randomly selected regional stations off San Diego, CA. Data are expressed as means over all stations in each group (see Figure E.2); ranges in parentheses are for individual replicate samples.

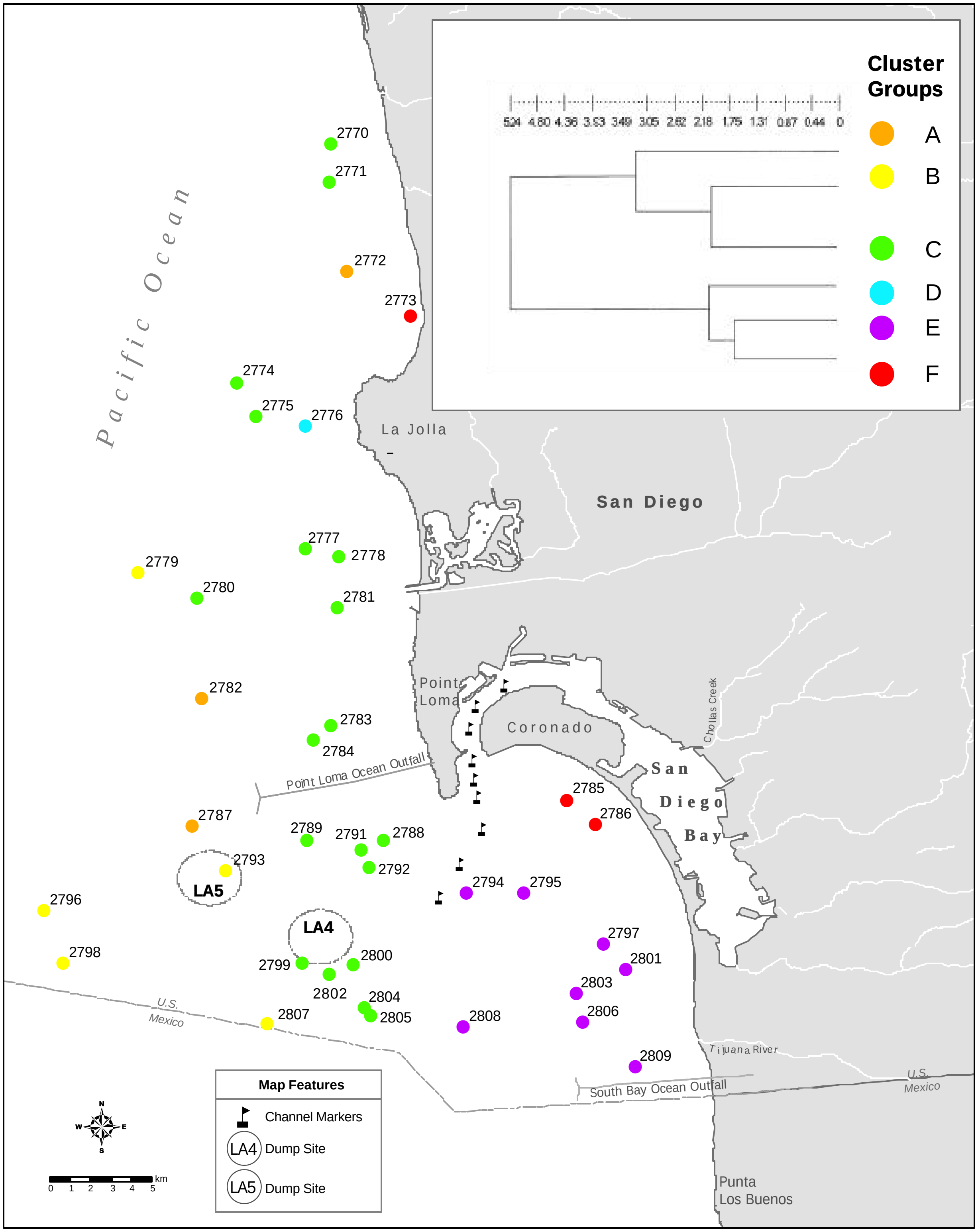
| Cluster Groups | Depth (m) | Cluster Group Description | Mean Phi | Sand % | Fines % | Total Organic Carbon | Total Nitrogen | Sulfides | Dominant taxa by abundance |
|---|---|---|---|---|---|---|---|---|---|
| Group A (n=3) | 194 (182-202) | Deep Water (slope) Fine Sediments | 5.1 (4.9-5.4) | 31 (23-35) | 69 (64-77) | 1.03 (0.8-1.2) | 0.11 (0.08-0.14) | 47.9 (0.9-134.0) | *Spiophanes fimbriata*<br>*Paradiopatra parva*<br>*Paraprionospio pinnata*<br>*Melinna heterodonta* |
| Group B (n=5) | 146 (130-152) | Outer-shelf Mixed sediments | 3.5 (1.1-4.4) | 69 (58-97) | 31 (2.5-42) | 0.59 (0.44-0.84) | 0.05 (0.04-0.07) | 2.0 (0.1-2.4) | *Paradiopatra parva*<br>*Tellina cadieni*<br>*Amphiodia digitata*<br>*Ampelisca careyi* |
| Group C (n=19) | 68 (44-94) | Mid-shelf Mixed Sediments | 4.1 (3.1-4.6) | 60 (42-84) | 40 (14-54) | 0.57 (0.31-0.79) | 0.06 (0.04-0.08) | 3.1 (0.1-17.7) | *Myriochele* sp M<br>*Amphiodia urtica*<br>*Amphiodia* sp<br>*Myriochele gracilis* |
| Group D (n=1) | 29 | Shallow Water All Coarse Sediments | 0.5 | 60 | 0 | 0.22 | 0.02 | 0 | *Spio maculata*<br>*Halistylus pupoideus*<br>*Caecum crebricinctum*<br>*Hesionura c. difficilis* |
| Group E (n=8) | 26 (18-43) | Shallow Water River delta | 2.9 (1.2-3.4) | 91 (86-100) | 9.3 (0-14) | 0.13 (0.05-0.21) | 0.02 (0.01-0.04) | 1.2 (0.5-2.7) | *Spiophanes bombyx*<br>*Tellina modesta*<br>*Spiophanes duplex* |
| Group F (n=3) | 14 (12-16) | Shallow Water Sandy Sediments | 2.6 (2.4-2.7) | 96 (93-98) | 4 (2-7) | 0.16 (0.1-0.23) | 0.02 | 1.1 (0.4-1.8) | *Photis macinerneyi*<br>*Rhepoxynius abronius*<br>*Diastylopsis tenuis*<br>*Tellina modesta*<br>*Owenia fusiformis* |

several organic indicators (i.e., sulfides, TOC and TN) and trace metals (see Appendix D). The deepest site (station 2772), located along the eastern edge of La Jolla Canyon, had the highest concentration of metals and organics of all the stations sampled. Cluster group A had the lowest species richness, abundance, diversity and dominance values of the six groups (Table E.3). Many of the most numerous and frequently occurring species were polychaetes, including the four most abundant species, *Spiophanes fimbriata*, *Paradiopatra parva*, *Paraprionospio pinnata* and *Melinna heterodonta*. Most other taxa were poorly represented.

Cluster group B consisted of five stations along the outer shelf (i.e., 130 – 150 m). These deepwater stations contained approximately one-half the amount of fine sediments and organic materials as at the cluster group A sites (Table E.1), a likely result of their position along the edge of the slope where current activity is typically strong. Cluster group B had the highest diversity and lowest dominance (i.e., highest Schwarz dominance value) of all six cluster groups, and the second highest species richness and abundance values (Table E.3). In contrast to cluster group A, polychaetes comprised approximately 50% of the taxa in group B, with increased numbers of crustaceans, molluscs and echinoderms making up the difference (Table E.4). For example, the four most abundant species each represented different phyla: one annelid (i.e., the polychaete *Paradiopatra parva)*, one mollusc (i.e., the bivalve *Tellina cadieni*), one arthropod (i.e., the amphipod *Ampelisca careyi*), and one echinoderm (i.e., the ophiuroid *Amphiodia digitata*).

Group C comprised the mid-shelf sites ranging in depth from 44 to 94 m, and included nearly one-half of the 39 stations sampled. This cluster group, characterized by mixed sediments, averaged about 40% fines and had the highest average species richness and abundance values. This assemblage is similar to what has been considered characteristic of the mainland shelf off southern California. The two most abundant species representing this mid-depth group included the polychaete *Myriochele* sp M and the ophiuroid *Amphiodia urtica*. *Myriochele* sp M is an opportunistic species whose populations vary greatly both spatially and temporally (see City of San Diego, 2002). For example, during this survey *Myriochele* sp M abundances ranged from 0 to 528 individuals per grab for this cluster group; however, if the two highest replicate samples are excluded, the mean abundance drops from 67 to 37 individuals per grab sample. *Amphiodia urtica*, a dominant species along the mainland shelf of southern California, was more evenly distrubuted. *Amphiodia urtica* ranged from 0 to 107 individuals per grab sample and averaged about 45 animals per 0.1 $m^2$ (Table E.2); however, this number underestimates actual populations since juveniles are difficult to identify and are usually recorded at either the genus (*Amphiodia*) or family (Amphiuridae) level. All three taxa were included among the top 10 most abundant species in this cluster group. Combined, these taxa result in an estimated population size for *A. urtica* that approaches 66 animals per sample. The polychaetes *Myriochele gracilis*, *Sternaspis fossor*, *Paradiopatra parva*, unidentifiable members of the polychaete family Maldanidae, as well as the sipunculid worm *Phascolion* sp A were also common members of this diverse assemblage.

Cluster group D consisted of a single, shallow station (2776) characterized by coarse sediments with no with no fine particles (i.e., 60% sand and 40% coarser materials). The assemblage at this site was quite different from all others and was dominated by polychaetes and molluscs. Of the four most abundant species, two polychaetes




## Figure E.2

Major station groups derived from cluster analysis of macrofaunal abundance data for the July 2002 survey of randomly selected regional stations off San Diego, CA.

## Table E.2

Dominant macroinvertebrates comprising cluster groups A-F derived from the July 2002 survey of randomly selected regional stations off San Diego, CA. Data are expressed as mean abundance per sample (no./0.1m$^2$) and represent the ten most abundant taxa in each group. Values for the three most abundant species (bolded) in each cluster group are underlined. n=number of station/survey entities per cluster group

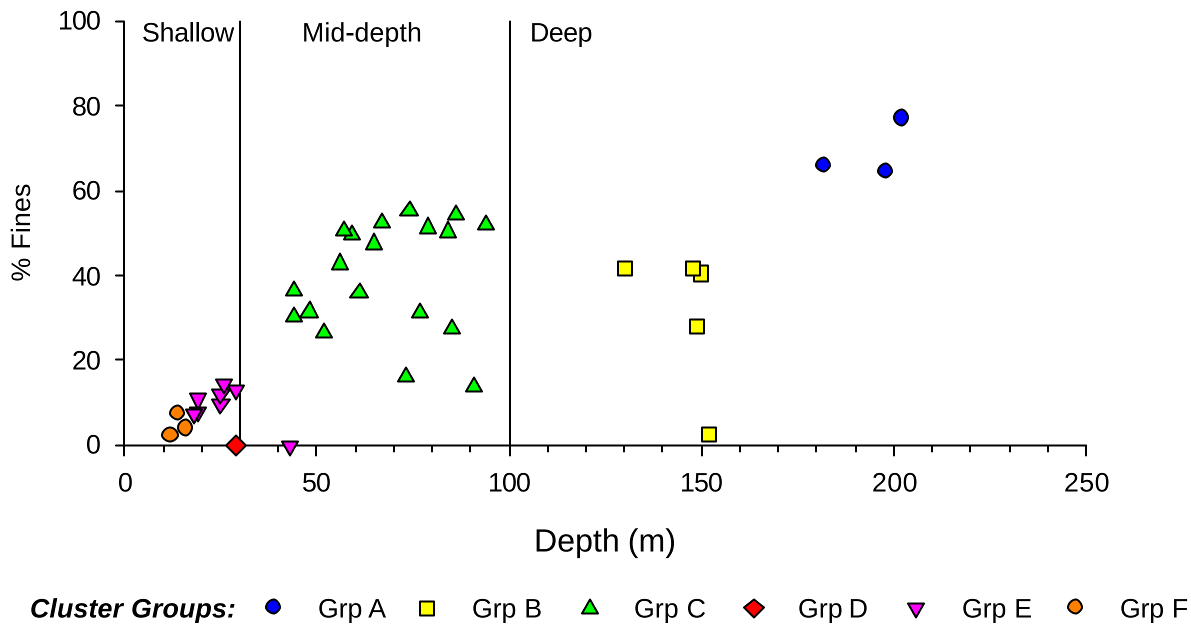
| Species/Taxa | Higher Taxa Code* | Cluster Groups A (n=3) | B (n=5) | C (n=19) | D (n=1) | E (n=8) | F (n=3) |
|---|---|---|---|---|---|---|---|
| ***Spiophanes fimbriata*** | P | **12.2** | 2.8 | 0.8 | | | |
| ***Paradiopatra parva*** | P | **9.0** | **8.6** | 3.6 | | 0.1 | |
| ***Paraprionospio pinnata*** | P | **7.2** | 1.2 | 1.1 | | 0.9 | |
| ***Melinna heterodonta*** | P | **7.0** | | | | | |
| *Praxillella pacifica* | P | 3.5 | 1.5 | 1.4 | | 0.1 | |
| Maldanidae | P | 2.8 | 2.6 | 4.4 | 0.5 | 2.9 | 0.3 |
| *Spiochaetopterus costarum* | P | 2.5 | 0.1 | 0.3 | 0.5 | <0.1 | 0.2 |
| *Parvilucina tenuisculpta* | M | 2.0 | 2.2 | 2.2 | | 0.1 | |
| *Magelona berkeleyi* | P | 2.0 | 0.2 | | | 0.1 | |
| ***Tellina cadieni*** | M | 1.7 | **7.4** | 0.7 | | | |
| *Mediomastus* sp | P | 1.7 | 1.2 | 2.2 | 0.5 | 1.4 | 2.2 |
| ***Myriochele gracilis*** | P | 0.8 | 2.8 | **12.4** | | 0.1 | |
| *Monticellina siblina* | P | 0.3 | 1.1 | 1.3 | | 3.0 | 0.2 |
| ***Myriochele* sp M** | P | 0.2 | 3.5 | **52.8** | | 3.3 | 0.2 |
| ***Amphiodia urtica*** | E | 0.2 | 2.6 | **45.6** | | 0.1 | |
| *Sternaspis fossor* | P | 0.2 | 2.5 | 8.4 | 0.5 | | |
| ***Amphiodia digitata*** | E | | **6.7** | 0.3 | | 0.2 | 0.5 |
| ***Ampelisca careyi*** | C | | **6.5** | 1.4 | | 0.1 | |
| *Proclea* sp A | P | | 5.3 | 7.2 | | | |
| *Leptochelia dubia* | C | | 5.2 | 2.5 | 3.0 | 1.0 | |
| *Exogone lourei* | P | | 5.2 | 0.5 | | 0.1 | 0.2 |
| ***Caecum crebricinctum*** | M | | 4.6 | 1.4 | **27.5** | | |
| Amphiuridae | E | | 4.2 | 5.9 | 0.5 | 1.0 | |
| ***Amphiodia* sp** | E | | 2.0 | **14.9** | | 0.6 | 0.3 |
| *Nephasoma diaphanes* | S | | 1.2 | 8.3 | | | |
| Nematoda | N | | 0.2 | 0.5 | 7.5 | 0.1 | |
| ***Spiophanes duplex*** | P | | 0.1 | 8.0 | | **4.9** | 1.5 |
| *Axinopsida serricata* | M | | 0.1 | 5.9 | 0.5 | | |
| *Hemilamprops californicus* | C | | 0.1 | 1.1 | | 3.1 | |
| *Limatula saturna* | M | | 0.1 | 0.1 | 7.5 | | |
| *Solariella peramabilis* | M | | 0.1 | | 8.5 | | |
| *Apionsoma misakianum* | S | | | 7.3 | 6.5 | 0.7 | |
| *Rhepoxynius menziesi* | C | | | 0.4 | | 2.8 | 5.8 |
| ***Spiophanes bombyx*** | P | | | 0.2 | 5.0 | **10.5** | 3.8 |
| *Owenia fusiformis* | P | | | 0.2 | 0.5 | 0.2 | 7.8 |
| ***Tellina modesta*** | M | | | 0.1 | | **7.6** | 8.8 |
| *Ampelisca cristata cristata* | C | | | 0.1 | 10.0 | 3.7 | |
| *Ampharete labrops* | P | | | <0.1 | | 1.8 | 4.0 |
| ***Diastylopsis tenuis*** | C | | | <0.1 | | 0.8 | **11.3** |
| *Ericthonius brasiliensis* | C | | | <0.1 | | | 5.2 |
| *Gibberosus myersi* | C | | | | | 0.3 | 5.2 |
| ***Halistylus pupoideus*** | M | | | | **30.5** | | |
| ***Hesionura coineaui diffic*** | P | | | | **23.0** | | |
| ***Photis macinerneyi*** | C | | | | | 0.1 | **30.5** |
| *Photis* sp OC 1 | C | | | | | 2.4 | |
| *Pisione remota* | P | | | | 8.5 | | |
| *Protodorvillea gracilis* | P | | | | 7.0 | | |
| ***Rhepoxynius abronius*** | C | | | | | 0.1 | **11.5** |
| ***Spio maculata*** | P | | | | **63.5** | | |

* P = Polychaeta (Annelida), C = Crustacea (Arthropoda), M = Mollusca, E = Echinodermata, S = Sipuncula.

(*Spio maculata* and *Hesionura coineaui difficilis*) and one gastropod (*Halistylus pupoideus*) were unique to this station. Two other polychaetes, *Pisione remota* and *Protodorvillea gracilis*, also occurred only at this site.

Group E consisted of eight shallow stations, six located offshore of the Tijuana River and two due south of the entrance to San Diego Bay. Stations within this group averaged approximately 91% sand and 9% fine sediments. Deposits discharged from the river and bay likely influenced the sediment composition of most stations within this group. One of the stations (2808), however, had no fine material and was located in an area known to consist of relict red sands. Overall, the benthic assemblage at these stations was typical for the region (see for example, City of San Diego 2001, 2002), and included two spionid polychaetes (*Spiophanes duplex* and *S. bombyx*), and the bivalve mollusc *Tellina modesta* as the dominant species. The other frequently occurring taxa in this assemblage were *Monticellina siblina*, *Myriochele* sp M, unidentified polychaetes of the family Maldanidae, and the crustaceans, *Ampelisca cristata cristata* (amphipod) and *Hemilamprops californicus* (cumacean).

Cluster group F comprised the three shallowest stations, all occurring at depths less than 16 m. The sediments at these sites had very little fine materials or organics, and the assemblages were dominated by crustaceans, including two amphipods, *Photis macinerneyi* and *Rhepoxynius abronius*, and a cumacean, *Diastylopsis tenuis*.




## Figure E.3

Sediment composition vs. depth for the 2002 regional survey of randomly selected stations off San Diego, CA. Data are expressed as the percent fines (<63$\mu$m) in the sediments at each station. See Table E.1 and Figure E.2 for details of cluster groups A-F.

## Table E.3

Summary of benthic community structure parameters from the July 2002 survey of randomly selected regional stations off San Diego, CA. Data are expressed as means per 0.1m$^2$ grab for: (A) species richness (SR); (B) abundance (Abun); (C) Biomass = grams, wet weight (BM); (D) Shannon diversity index (H'); (E) Swartz dominance index (Dom) (F) infaunal trophic index (ITI); (G) benthic response index (BRI).

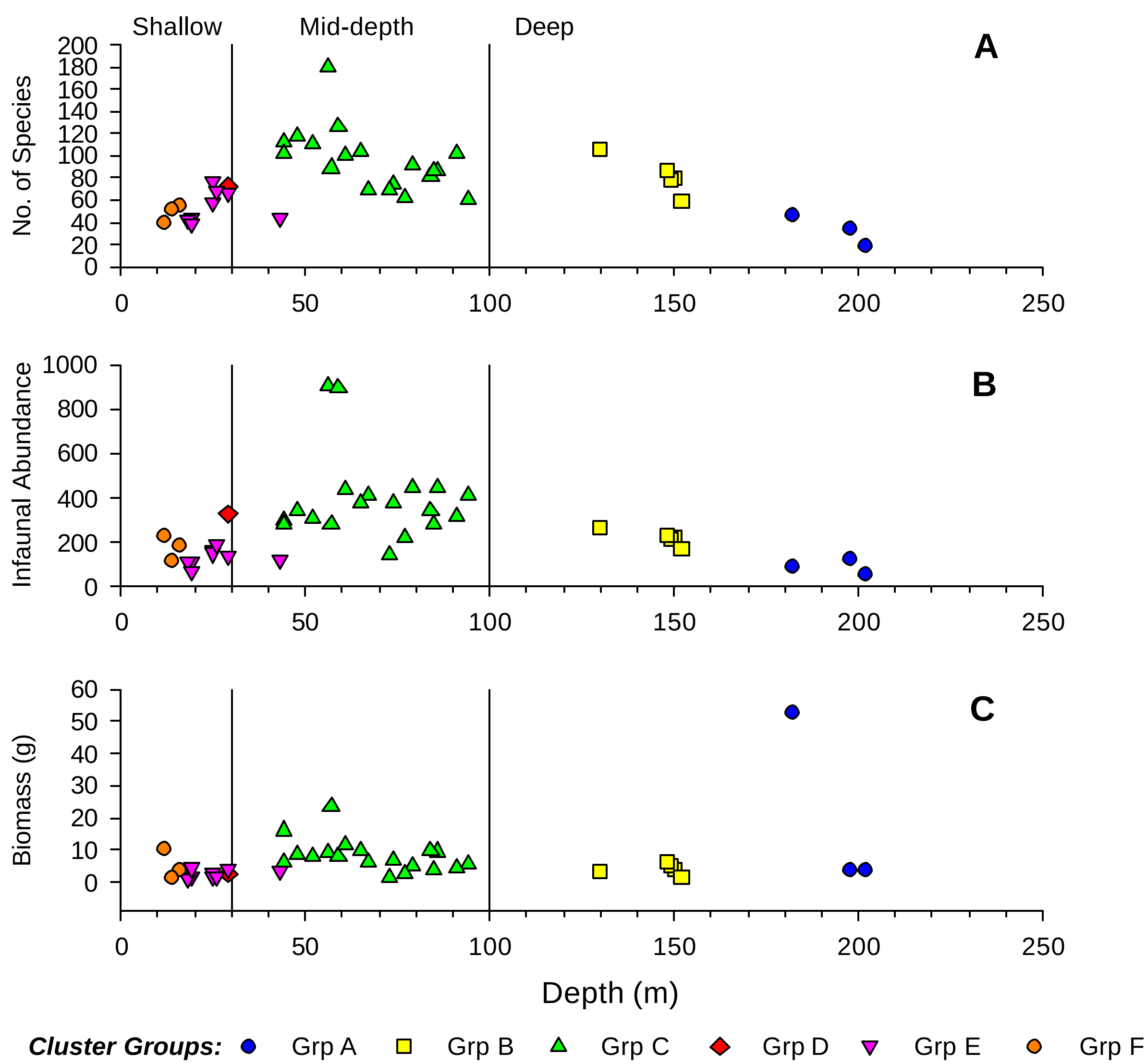
| Cluster Group | Station | Depth (m) | SR | Abun | BM | H' | J' | Dom | ITI | BRI |
|---|---|---|---|---|---|---|---|---|---|---|
| **A** | 2772 | 202 | 19 | 50 | 3.3 | 2.2 | 0.8 | 8 | 54 | 42.3 |
| | 2782 | 198 | 35 | 122 | 3.6 | 3.0 | 0.8 | 14 | 84 | 17.5 |
| | 2787 | 182 | 46 | 88 | 52.8 | 3.4 | 0.9 | 24 | 82 | 8.2 |
| | **Mean** | **194** | **33** | **87** | **19.9** | **2.9** | **0.9** | **15** | **73** | **23** |
| **B** | 2779 | 150 | 81 | 224 | 3.6 | 4.0 | 0.9 | 34 | 80 | 11.0 |
| | 2793 | 130 | 105 | 268 | 3.3 | 4.2 | 0.9 | 44 | 84 | 3.7 |
| | 2796 | 149 | 78 | 216 | 5.0 | 3.8 | 0.9 | 31 | 82 | -0.9 |
| | 2798 | 152 | 60 | 171 | 1.4 | 3.7 | 0.9 | 24 | 84 | 0.5 |
| | 2807 | 148 | 86 | 232 | 6.6 | 4.0 | 0.9 | 36 | 89 | 4.4 |
| | **Mean** | **146** | **82** | **222** | **4.0** | **4.0** | **0.9** | **34** | **83** | **3.8** |
| **C** | 2770 | 44 | 113 | 302 | 6.0 | 4.2 | 0.9 | 47 | 83 | 9.3 |
| | 2771 | 56 | 180 | 903 | 9.3 | 4.4 | 0.9 | 54 | 87 | 9.1 |
| | 2774 | 86 | 87 | 445 | 9.5 | 3.3 | 0.7 | 17 | 81 | 0.3 |
| | 2775 | 59 | 127 | 896 | 7.9 | 3.1 | 0.6 | 19 | 78 | 5.8 |
| | 2777 | 57 | 89 | 281 | 23.5 | 3.6 | 0.8 | 28 | 90 | 10.8 |
| | 2778 | 44 | 102 | 278 | 16.0 | 4.1 | 0.9 | 38 | 83 | 16.7 |
| | 2780 | 94 | 60 | 414 | 5.4 | 2.5 | 0.6 | 7 | 79 | 0.6 |
| | 2781 | 48 | 118 | 343 | 8.6 | 4.3 | 0.9 | 47 | 81 | 17.2 |
| | 2783 | 67 | 69 | 415 | 6.1 | 2.7 | 0.6 | 10 | 80 | 10.2 |
| | 2784 | 74 | 75 | 375 | 7.0 | 3.0 | 0.7 | 14 | 88 | 2.1 |
| | 2788 | 52 | 111 | 312 | 8.0 | 4.1 | 0.9 | 44 | 85 | 15.3 |
| | 2789 | 84 | 81 | 344 | 9.9 | 3.2 | 0.7 | 18 | 83 | 3.5 |
| | 2791 | 65 | 104 | 377 | 10.0 | 3.7 | 0.8 | 34 | 91 | 9.3 |
| | 2792 | 61 | 101 | 442 | 11.8 | 3.6 | 0.8 | 27 | 91 | 10.2 |
| | 2799 | 91 | 102 | 317 | 4.6 | 4.1 | 0.9 | 38 | 80 | 2.2 |
| | 2800 | 79 | 91 | 445 | 5.0 | 3.2 | 0.7 | 20 | 79 | 7.0 |
| | 2802 | 85 | 87 | 284 | 3.6 | 3.5 | 0.8 | 25 | 82 | 1.8 |
| | 2804 | 77 | 62 | 221 | 2.7 | 3.2 | 0.8 | 18 | 83 | 5.1 |
| | 2805 | 73 | 70 | 144 | 1.3 | 3.9 | 0.9 | 34 | 81 | 9.7 |
| | **Mean** | **68** | **96** | **397** | **8.2** | **3.6** | **0.8** | **28** | **83** | **7.7** |
| **D** | **2776** | **29** | **73** | **327** | **2.7** | **3.3** | **0.8** | **19** | **70** | **7.5** |
| **E** | 2794 | 29 | 66 | 142 | 4.0 | 3.9 | 0.9 | 31 | 83 | 21.9 |
| | 2795 | 25 | 77 | 168 | 3.0 | 4.1 | 0.9 | 37 | 81 | 24.5 |
| | 2797 | 19 | 45 | 116 | 1.4 | 3.3 | 0.9 | 19 | 80 | 10.9 |
| | 2801 | 18 | 42 | 111 | 1.0 | 3.1 | 0.8 | 15 | 80 | 14.8 |
| | 2803 | 25 | 58 | 151 | 1.8 | 3.7 | 0.9 | 25 | 83 | 20.6 |
| | 2806 | 26 | 69 | 188 | 1.4 | 3.8 | 0.9 | 28 | 81 | 19.9 |
| | 2808 | 43 | 44 | 121 | 3.2 | 3.3 | 0.9 | 18 | 83 | 14.5 |
| | 2809 | 19 | 39 | 70 | 4.3 | 3.4 | 0.9 | 22 | 83 | 7.3 |
| | **Mean** | **26** | **55** | **133** | **2.5** | **3.6** | **0.9** | **24** | **82** | **16.8** |
| **F** | 2773 | 16 | 55 | 183 | 3.6 | 3.4 | 0.8 | 20 | 85 | 6.2 |
| | 2785 | 12 | 40 | 228 | 10.2 | 2.5 | 0.7 | 8 | 74 | 9.1 |
| | 2786 | 14 | 51 | 112 | 1.0 | 3.6 | 0.9 | 24 | 73 | 17.8 |
| | **Mean** | **14** | **49** | **174** | **5.0** | **3.1** | **0.8** | **17** | **77** | **11.0** |

**Community Parameters**

***Number of Species***

A total of 766 macrobenthic taxa were identified during the July 2002 survey, slightly fewer (6%) than the previous year. Rare or unidentifiable species that occurred only once accounted for approximately 19% of these taxa.

Species richness (i.e., the number of species per sample) ranged from 19 to 180 species per 0.1 m$^2$ grab in 2002 (Table E.3, Figure E.4a). The number of species varied among stations within cluster groups, but was generally




## Figure E.4

Summary of benthic community parameters vs. depth for the 2002 regional survey of randomly selected stations off San Diego, CA. Data are expressed as means per station for each 0.1m$^2$ grab for: (A) species richness; (B) abundance; (C) biomass = grams, wet weight; (D) Shannon diversity index (H'); (E) infaunal trophic index; (F) benthic response index. See Table E.1 and Figure E.2 for details of cluster groups A-F.

highest among the mid-shelf stations (i.e., cluster group C). For example, almost all stations with >100 species per sample were located at mid-shelf depths (e.g., stations 2771, 2770, 2775, 2781 and 2788). In contrast, species richness was lowest among the deepwater sites (i.e., cluster group A), followed by the shallow sites composing cluster groups E and F.

Polychaetes were generally the most diverse of the major taxa, and with one exception (i.e., cluster group F), comprised over 40% of the species among the cluster groups (Table E.4). They represented over 70% percent of the species found in the cluster group A assemblage. Crustaceans represented from about one-quarter to one-

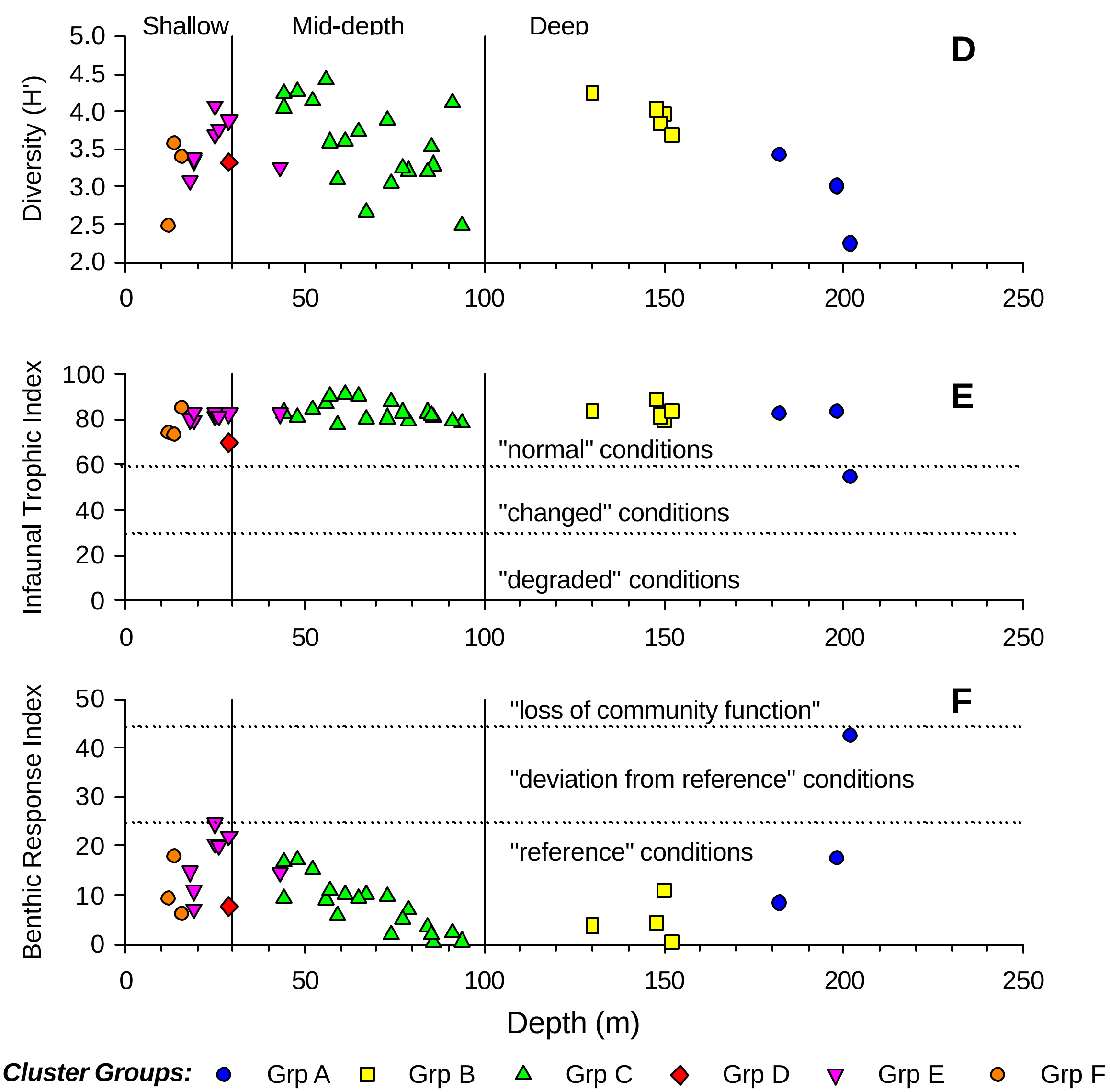



**Figure E.4** **(continued)**

## Table E.4

Summary of composition of the benthic community comprising cluster groups A-F derived from the July 2002 survey of randomly selected regional stations off San Diego, CA. Data are expressed as the mean and percent composition per cluster group for the major categories: Polychaetes, Crustacea, Mollusca, Echinodermata (non-ophiuroids and ophiuroid taxa combined, except for biomass), and all other taxa combined.

| | Cluster | Polychaetes | | Crustacea | | Mollusca | | Non-ophiuroid Echinodermata | | Ophiuroid Echinodermata | | Other taxa | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | Mean | % | Mean | % | Mean | % | Mean | % | Mean | % | Mean | % |
| Species Richness | A | 23 | 72 | 3 | 7 | 4 | 12 | 2 | 6 | . | . | 1 | 4 |
| | B | 45 | 55 | 21 | 26 | 8 | 9 | 7 | 8 | . | . | 3 | 4 |
| | C | 45 | 46 | 22 | 23 | 15 | 16 | 6 | 7 | . | . | 9 | 10 |
| | D | 30 | 41 | 16 | 22 | 12 | 16 | 5 | 7 | . | . | 12 | 16 |
| | E | 23 | 42 | 15 | 27 | 10 | 18 | 2 | 4 | . | . | 5 | 10 |
| | F | 13 | 27 | 18 | 38 | 12 | 24 | 2 | 5 | . | . | 4 | 8 |
| Abundance | A | 70 | 82 | 4 | 4 | 8 | 9 | 3 | 3 | . | . | 1 | 2 |
| | B | 122 | 54 | 52 | 24 | 23 | 11 | 21 | 9 | . | . | 4 | 2 |
| | C | 199 | 49 | 50 | 14 | 40 | 10 | 73 | 20 | . | . | 34 | 7 |
| | D | 153 | 47 | 38 | 12 | 95 | 29 | 14 | 4 | . | . | 29 | 9 |
| | E | 64 | 47 | 34 | 26 | 23 | 18 | 3 | 2 | . | . | 8 | 6 |
| | F | 36 | 24 | 99 | 52 | 29 | 18 | 4 | 2 | . | . | 7 | 4 |
| Biomass | A | 1.9 | 44.5 | 0.0 | 0.5 | 0.2 | 5.0 | 16.3 | 30.8 | 1.5 | 18.5 | 0.1 | 0.6 |
| | B | 0.9 | 25.6 | 0.1 | 4.1 | 0.2 | 9.0 | 1.5 | 26.0 | 1.2 | 32.9 | 0.1 | 2.4 |
| | C | 1.8 | 24.5 | 0.2 | 3.0 | 1.8 | 15.5 | 0.8 | 8.7 | 3.1 | 40.5 | 0.5 | 7.8 |
| | D | 0.5 | 17.3 | 0.3 | 10.5 | 1.1 | 40.6 | 0.4 | 16.2 | 0.1 | 5.6 | 0.3 | 9.8 |
| | E | 0.9 | 43.3 | 0.2 | 7.2 | 0.8 | 27.7 | 0.4 | 9.6 | 0.1 | 3.5 | 0.2 | 8.7 |
| | F | 0.7 | 21.7 | 0.2 | 6.8 | 3.7 | 58.9 | 0.1 | 3.5 | 0.1 | 2.5 | 0.2 | 6.6 |

third of the taxa at nearly all sites, except those along the slope (cluster group A) where they comprised only 7% of the total species collected. Molluscs represented 9 – 24% of the species per site, echinoderms from 4 to 6%, and all remaining phyla from 4 to 10%.

### *Infaunal Abundance*

Macrofaunal abundance was also highly variable in the region, ranging from 50 to 903 animals per sample (Table E.3, Figure E.4b). Peak abundance occurred at the mid-depth stations (station group C), where densities averaged about 397 animals per sample. Two northern sites (stations 2771 and 2775) had the highest abundance values (903 and 896, respectively), more than twice that of any other station. These two stations were dominated by polychaetes (> 450/sample) and sipunculid worms (> 100/sample). The opportunistic oweniid polychaete, *Myriochele* sp M, accounted for over 30% of the individuals at station 2775. The lowest abundance values occurred at the deepwater sites comprising cluster group A, followed by the shallow stations off the Tijuana River (i.e., cluster group E).

Polychaetes were generally the most abundant taxa, representing from 24 to 82% of the organisms collected per cluster group (Table E.4). The one exception to this pattern was the shallow-water cluster group F where crustaceans were numerically dominant (i.e., 52%). Crustaceans, molluscs or echinoderms, depending upon depth, sediment composition or amount of disturbance at the various sites, represented the second and third most abundant taxa. For example, crustacean abundance was highest among sites where current activity is presumed to be relatively high (e.g., the outer shelf, or shallow waters), while molluscs were more prominent in areas of relatively coarse sediments, typical of shallow water environments. Echinoderms, on the other hand, were one of the dominant or co-dominant taxa of the outer- and mid-shelf assemblages (groups B and C) where sediments were well mixed. All other taxa combined accounted for 2-9% of infaunal abundance in the various assemblages.

***Biomass***

Biomass values were also quite variable, averaging between 1.0 and 52.8 g per station (Table E.3, Figure E.4c). The total biomass was generally higher at the mid-depth sites, where echinoderms (i.e., primarily ophiuroids) accounted for most of the benthic biomass (i.e., cluster groups B and C, Table E.4). In contrast, molluscs accounted for a large portion of the biomass values at some of the shallower assemblages (i.e., cluster groups D and F). Relatively high biomass values (> 10 g/sample) were typically associated with the collection of a few large animals (e.g., echinoids, holothuroids, gastropods) or large numbers of individual taxa (e.g., ophiuroids or molluscs), a pattern similar to that seen throughout the Southern California Bight. For example, approximately 88% of the total biomass at deepwater station 2787 was due to four specimens of the echinoid *Brisaster latifrons*.

***Species Diversity and Dominance***

Species diversity varied among stations, with H' values ranging from 2.2 to 4.4 (Table E.3, Figure E.4d). Although, H' at most sites was between 3.0 and 4.0, stations with the highest diversity (i.e., H' $\geq$4.0) were located along the outer- and mainland shelf (i.e., cluster groups B and C, respectively). The lowest values occurred at three distant stations, one each from the deep, mid-shelf and shallow water station groups. Station 2772, a deepwater site located along the edge of La Jolla Canyon, had the highest percentage of fine sediments as well as the lowest species richness of any station. Station 2780, a mid-shelf station off Mission Bay was dominated by *Myriochele* sp M, an oweniid polychaete that accounted for over 40% of the total abundance. Finally, station 2785, a shallow, sandy site off Coronado, was dominated by *Photis macinerneyi*, an amphipod crustacean that accounted for about 40% of this station's total abundance.

Dominance, measured as the minimum number of species comprising 75% of a community by abundance (see Swartz 1978), is inversely proportional to numerical dominance. These values also varied widely throughout the region, and averaged from 7 to 54 species per station. The pattern of dominance across cluster groups was similar to that for diversity. Dominance was highest (i.e., low values for Swartz dominance) among those stations with low diversity values, such as those mentioned above and low among stations comprising cluster group B.

***Environmental Disturbance Indices: ITI and BRI***

Average Infaunal Trophic Index (ITI) values were generally similar to those of previous years. With one exception (station 2772), average ITI values ranged from 73 to 91 throughout the San Diego region (Table E.3, Figure E.4e), even among stations identified as having relatively high amounts of chemical contamination (see Appendix D, stations 2789, 2793, 2799, 2800, 2803). These relatively high values (i.e., > 60) are generally considered characteristic of "normal" benthic conditions (Bascom et al. 1979, Word 1980).

Similarly, Benthic Response Index (BRI) values at most stations were indicative of undisturbed communities or "reference conditions." Index values below 25 (on a scale of 100) suggest undisturbed communities or "reference conditions," while those in the range of 25-33 represent "a minor deviation from reference condition," which may or may not reflect anthropogenic impact (see Smith et al. 2001). Values greater than 44 indicate a loss of community function. Only station 2772 had a BRI that exceeded the critical threshold of 33 (See Table E.3).

The low ITI and high BRI values at station 2772 (54 and 42, respectively) were not unexpected. This station was in La Jolla Canyon, contained very fine sediments, and had relatively high organic and trace metal contamination. Both environmental indices are sensitive to each of these conditions, and seem to accurately reflect the generally low species richness and abundance that was present at this site.

## SUMMARY & CONCLUSIONS

The Southern California Bight (SCB) benthos has long been considered a "patchy" habitat, with the distribution of species and communities varying in space and time. Barnard and Ziesenhenne (1961) described the SCB shelf as consisting of an *Amphiodia* "mega-community" with other sub-communities representing simple variations determined by differences in substrate type and microhabitat. Results of the 2002 and previous regional surveys off San Diego generally support this characterization (e.g., see City of San Diego 1999, 2000b, 2001, 2002). The 2002 benthic assemblages segregated mostly due to differences in habitat (e.g., depth and sediment grain size), with little evidence of anthropogenic impact. Over 50% of the benthos off San Diego was dominated by the ophiuroid genus *Amphiodia*, with *A. urtica* or *A. digitata* representing the dominant or co-dominant species (cluster groups B and C). In contrast, the dominant species of the other four assemblages varied according to the sediment type or depth specific to their location. The benthos at only one station (2772) appears to have been effected by the presence of various contaminants, which may be related to the close proximity of the La Jolla Canyon.

Two distinct benthic assemblages (i.e., cluster groups B and C) identified during the 2002 survey were, in combination, similar to the *Amphiodia* "mega-community" described by Barnard and Ziesenhenne (1961). The assemblage representing cluster group B occurred in deeper water along the outer shelf (130-152 m), and was dominated by amphiurid ophiuroids, including *Amphiodia digitata*, *A. urtica* and juveniles identified as either *Amphiodia* sp or Amphiuridae. The co-dominant species within this assemblage included other taxa common to this group such as *Paradiopatra parva*, *Tellina cadieni* and *Ampelisca careyi.* Cluster group C occurred along the mainland shelf at depths ranging from 44 to 94 m and where the sediments were composed of relatively fine particles (e.g., mean phi of 4.1 with 40% fines). In addition to *A. urtica* and the opportunistic oweniid polychaete *Myriochele* sp M, other species characteristic of this community included another oweniid, *Myriochele gracilis*, the spionid polychaete *Spiophanes duplex*, the sternaspid polychaete *Sternaspis fossor*, and the bivalve mollusc *Axinopsida serricata*. Similar ophiuroid-polychaete dominated assemblages have been described by Jones (1969), Fauchald and Jones (1979), Thompson et al. (1987, 1992, 1993), EcoAnalysis et al. (1993), Zmarzly et al. (1994), Diener and Fuller (1995) and Bergen et al. (1998, 2001).

Shallow water assemblages (e.g., < 30 m) in the region were highly variable depending upon their sediment type, but these assemblages were generally similar to other shallow, sandy sediment communities in the SCB (see Barnard 1963, Jones 1969, Thompson et al. 1987, 1992, ES Engineering-Science 1988). At many of these stations, species such as the polychaetes *Spiophanes bombyx* and *S. duplex*, the bivalve *Tellina modesta*, the amphipods *Rhepoxynius abronius* and *Photis macinerneyi*, and the cumacean *Diastylopsis tenuis* become numerically dominant. However, the assemblage at the single site (station 2776) that constituted cluster group D was characterized by unique, coarse sediments composed of relict red or black sands that are typically associated with distinct benthic assemblages. This assemblage was dominated by the polychaetes *Spio maculata* and *Hesionura c. difficulis*, and the gastropods *Halistylus pupoideus* and *Caecum crebricinctum*, with all but the latter species being unique to this station.

The three deepest sites (>180 m) had the highest percentage of fine particles, organic materials and trace metal contamination in the region. These sites alos had the lowest species richness, diversity and abundance, and were dominated by polychaetes, including *Spiophanes fimbriata*, *Paradiopatra parva*, *Paraprionospio pinnata*, and *Melinna heterodonta*. The deepest station (2772) with the greatest amount of fine sediments and the highest levels of organic and trace metal contamination was also the only station that had BRI and ITI values representative of “changed” benthic conditions.

Although the results of the 2002 regional survey off San Diego indicated that benthic communities may be affected by the accumulation of organic material and trace metals within the fine sediments common at some deepwater sites, there was scant evidence of anthropogenic impacts from known point-sources. The benthic assemblages present in the vicinity of the South Bay and Point Loma ocean outfalls, as well as the dredged materials disposal sites, are representative of those known to occur in undisturbed sediments in spite of any apparent contaminant load (see Appendix D). There was also little clear evidence that local bays or non-point sources adversely affected benthic communities. Abundances of soft-bottom invertebrates exhibit substantial spatial and temporal variability that may mask the effects of natural or anthropogenic disturbances (Morrisey et al. 1992a, 1992b, Otway 1995). Future region-wide surveys may provide additional information useful in understanding these types of disturbances.

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# Appendix F

## Coastal Remote Sensing of the San Diego/Tijuana Region

## (July 2002)

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# Appendix F

# Coastal Remote Sensing of the San Diego/Tijuana Region

## INTRODUCTION

Imagery from satellite data and aerial sensors produces a synoptic look at surface water clarity that is not possible using shipboard sampling alone. Analysis of seawater samples requires various laboratory tests while CTD casts require further data processing, both of which can add considerable time to the interpretation of water quality conditions. Sampling at fixed stations once a week or once a month results in inconvenient, albeit unavoidable, gaps in assembled time series of coastal water quality data. With public health issues a paramount concern of ocean monitoring programs, any information that helps to provide a clearer and more complete picture of water conditions is of benefit to the general public as well as to program managers and researchers. Having access to a large-scale overview of surface waters within a few hours of image collection also has the potential to bring the monitoring program closer to real-time diagnosis of possible contamination conditions.

For the above reasons, the City of San Diego, the United States International Boundary and Water Commission, and the San Diego Regional Water Quality Control Board have contracted with Ocean Imaging Corporation (Solana Beach, CA) to conduct an aerial/satellite remote sensing program for the San Diego/Tijuana region as part of the ocean monitoring programs for the Point Loma and South Bay ocean outfalls. One objective of this multi-year project is to determine any relationships between the various types of imagery data and field-collected data. The investigators and sponsors of this research project recognize that a major limitation of aerial and satellite images is that they only provide information about surface waters (~0-15 m) without providing any direct information regarding water movements, water color, or water clarity in deeper layers. However, initial reports demonstrate the breadth of information that may be provided by remotely sensed data.

Although quantitative measures are still under development, early results have demonstrated interesting patterns of turbidity sources and distribution in the region of the South Bay Ocean Outfall (SBOO). Researchers have contended since the South Bay monitoring program began that most incidents of elevated bacterial counts along the shoreline were likely due to land-based contamination (e.g., terrestrial and riverine runoff) rather than the onshore transport of the wastewater plume from the outfall. However, there was little direct evidence to either support or reject this hypothesis. Now, images captured coincident with field samples as part of the remote sensing project are adding support to the land-based source hypothesis. For example, expansive views of the coastline following rainfall events have identified up to 10 separate point sources of significant turbidity plumes to coastal waters off San Diego (Ocean Imaging, 2000). The images often geographically pinpoint the origin of different plumes and help to differentiate between the turbidity contributions of river discharges, surf zone sediment resuspension events, and storm drain effluents. The extent of these plumes can exceed 10 km from shore and at times have been seen to envelop the surface waters immediately above the outfall terminus.

Image interpretation has also been shown to provide useful information regarding the visible impacts of lagoon dredging, the extent and longevity of plankton blooms, the extent of surface dispersal of land-based turbidity sources, indicators of upwelling, and the net movements of surface waters. There are even indications that material discharged through the SBOO may have a discernable spectral signature when it reaches surface waters during the winter months. For example, images reported to show plume discharge at the surface were taken at the same time that high bacterial concentrations were recorded in samples from surface waters above the discharge site.

Quantitative data explorations currently underway should confirm whether or not discharged material can be recognized as spectrally distinct from naturally occurring marine waters. In addition, continued interpretation of images collected in concert with field sampling should begin to show how often land-based plumes are correlated with samples that register elevated bacterial counts, high total suspended solids, high chlorophyll concentrations or low transmissivity values. Future research combining the results of image interpretation with the Scripps Institution of Oceanography's CODAR surface current measurement system should provide a clear picture of how surface currents influence the distribution of suspended materials. Further analysis into the effects of rainfall events may continue to elucidate the role of terrestrial sources in beach contamination events.

Surface currents, however, have been shown by previous research projects to be of limited use in determining bottom water currents (Hendricks, 1994). It is also unlikely that aerial or satellite imagery will provide definitive differentiation between land-based contamination and outfall contamination. Although remote sensing data looks to be meaningful when applied to the origins of surface water contamination, how much it will divulge about the fate of outfall discharges that originate in deeper waters remains to be seen.

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